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DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

# MINERAL RESOURCES

OF THE

# UNITED STATES

# 1916

H. D. McCASKEY
Geologist in Charge, Division of Mineral Resources

PART I—METALS
H. D. MCCASKEY, Geologist in Charge

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

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# INSERT.


Mineral products of the United States, 1907–1916 ..... In pocket.

# MINERAL PRODUCTION OF THE UNITED STATES.

## INTRODUCTION.

By H. D. McCaskey.

### SCOPE OF REPORT.

The report of the United States Geological Survey on the mineral resources of the United States for 1916 marks the thirty-fifth year for which such reports have been published. The present summary sets forth the essential statistics embodied in the separate chapters of the report for 1916. Owing to the lateness of publication resulting from the delay caused by urgent war work, the summary is presented in the briefest possible form, the elaboration of its many interesting features being left for reports for subsequent years.

The reader who is interested in any particular mineral industry should consult the chapters on that industry for 1916 and preceding years. The statistics and the current data for all the minerals considered are given each year, but special features are discussed more fully in some years than in others, and therefore only a complete report, such as it has been planned to publish at intervals for each subject, will contain a treatment in detail.

The chapters for 1916 have been published in separate form as fast as completed, many of them months in advance of the volumes, and the essential final statistics and reviews were given to the press for most of the minerals even before the separates were published. These press notices were preceded by preliminary reviews and close estimates of production, imports, and exports for 1916, which were given to the press a few days after the end of the year. The volumes (Part I, Metals, and Part II, Nonmetals) are therefore the final repositories of the information for the year, but their appearance does not at all indicate the dates on which the information they contain was given out and made available for use.

### MINERAL PRODUCTION.

#### GENERAL.

The statistics of production include comparison with earlier years, the figures for which are carried forward each year for convenient reference. This series of reports constitutes a history of the mineral industry in the United States from 1880 to date, and anyone who desires to make a complete study of the progress in the production and utilization of any one mineral substance should consult all the volumes. Some information on the occurrence, development, trade conditions, and use of minerals and some descriptions of mining districts are not carried forward from year to year, but are given more fully in certain years than in others. For statistics carried forward,

however, the reader should consult the latest volume, as it contains any revision made, not only of the reports for the years preceding but also of the reports published separately in advance of the volume. In preparing the report for 1915 a special and exhaustive comparison and study of figures for earlier years was made by Miss M. B. Clark, who has revised all the statistics from the earliest volume to the present. Each volume is a supplement to all that have preceded, and the summaries for 1915 and later years should be used in preference to those of earlier date. The figures for imports and exports have been compiled by James A. Dorsey, of the Geological Survey, from records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce.

## VALUES ASSIGNED TO PRODUCTION.

The value of the contribution of our metallic production to our industrial needs is best shown by determining the value of the refined or partly refined metal—the marketable product. This value is, of course, ordinarily greater than the value of the ores from which the products are obtained, and the movement of bullion, matte, and refined metal does not at all indicate the volume of ore transported by the railroads and other carriers or the demands made on the transportation lines by the mineral industry as compared with the agricultural and other industries. During recent years the compilation of the statistics of pig-iron production has been supplemented by an accurate determination of the quantity and the value of the iron ore produced, but the quantity and value of pig iron have been retained as units for the iron industry. Many of the ores of the precious and semiprecious metals are complex associations of several metals and gangues, and the same ore may have different values, or none, its value depending on the metallurgic and other treatment it may require. The quantities and values of such ores are therefore best measured by the metal actually extracted from them and made marketable. Chromic iron ore, manganese ore, manganiferous ores, and bauxite, on the other hand, are marketed as such. The quantities and the values of the nonmetals are likewise placed upon the products in the condition in which they are first sold. The quantities and values of the fuels, phosphate rock, and some other nonmetals therefore represent raw or only very slightly dressed products, in the condition in which they first become articles of trade. Salt appears as the content of brine, in various refined conditions, or as rock salt. Gypsum is sold as crude, as ground, or as calcined. Cement, however, is the commercial product reported, rather than the raw material from which it is made. The clay products, except very small quantities of special clays that are sold raw, first appear in statistics as brick, terra cotta, tile, porcelain, pottery, etc. As quarry products are sold in three forms—rough, partly dressed, or finished—there is no way of determining their quantities and values except by considering them in the condition in which they are first marketed.

In the tables on pages 46a–70a the value of the iron ore produced is credited to the States in which the ore is mined. In an ideal apportionment the value of the pig iron produced from ore mined in any State should be credited to that State, by the method adopted for gold, silver, copper, lead, and zinc, but it has not yet proved practicable to apply this method to iron.

## HISTORICAL REVIEW.

The first detailed report of the United States Geological Survey on the mineral resources of the United States was that for 1882, and since that year Congress has annually specifically appropriated funds for the work. Figures showing the mineral production of the country are available from the census returns for 1880, however, and comparisons are possible from that year to date. The statistics for many individual minerals for still earlier years have been compiled by the Survey's specialists.

In 1880, according to the Tenth Census, the population of the United States was 50,189,209 and the value of the mineral products was $367,463,000—a per capita value of $7.32. In 1910, according to the Thirteenth Census, the population had increased to 91,972,266, a gain of about 80 per cent, and the value of mineral products to $1,991,216,000, an increase in 30 years of $1,623,753,000, or more than 440 per cent, and an average value per capita of $21.65. In 1916, according to the Bureau of the Census, the population had increased to 101,032,339, and as the mineral production for that year amounted to $3,513,934,000, the value of the per capita output was $34.78. Therefore, from 1880 to 1916 the population increased 50,843,000, or 101 per cent; the value of the mineral products increased $3,146,000,000, or 856 per cent; and the per capita value increased $27.46, or 375 per cent.

A comparison of the output of the principal six metallic and six nonmetallic mineral products in 1880 and 1916 shows the following notable changes:

*Value of certain mineral products in 1880 and 1916.*

| Product. | 1880 | 1916 | Product. | 1880 | 1916 |
|---|---|---|---|---|---|
| METALS. | | | NONMETALS. | | |
| Iron | $89,315,569 | $663,478,118 | Coal [a] | $95,640,396 | $867,125,638 |
| Gold | 36,000,000 | 92,590,300 | Petroleum | 24,600,638 | 330,899,868 |
| Silver | 34,717,000 | 48,953,000 | Salt | 4,829,566 | 13,645,947 |
| Copper | 12,942,720 | 474,288,000 | Cement | 1,852,707 | 104,689,090 |
| Lead | 9,572,500 | 76,207,000 | Phosphate rock | 1,123,823 | 5,896,993 |
| Zinc | 2,863,080 | 151,005,000 | Natural gas | [b] 215,000 | 120,227,468 |

[a] Including bituminous, anthracite, and other coal.
[b] For 1882; none in 1880 and 1881.

The production of iron was 3,375,912 long tons in 1880 and increased to 39,126,324 tons in 1916, passing the previous high records of both quantity and value for 1913. The value of the great iron production of 1916 exceeded the value of total mineral production of the United States for every year up to 1898, the year of the Spanish-American war. The iron industry dates back to colonial days, and an output of over 1,000,000 tons of pig iron was reached as early as 1864. The great ore field of the Marquette Range has also had a long and impressive record, antedating by 26 years this series of reports.

The production of gold in 1916 was 4,479,056 fine ounces, a decrease from 4,887,602 ounces, valued at $101,035,700, in 1915 (the high-water mark), and from 4,572,976 fine ounces in 1914. The output of 1916 was also lower than that of each of the years 1912, 1911, 1910,

1909, 1908, and 1906, but was higher than all others, except 1915 and 1914, mentioned. The great Alaskan production has been a marked factor in the increase of domestic gold production since 1880, as has the development of such new important camps as Cripple Creek, Goldfield, and Tonopah. In the review for 1914 the writer pointed out that the production was probably then at the full rate of the known workable resources and that it did not seem probable that the total gold output of the United States and Alaska would exceed $100,000,000 at best.

As new deposits are developed old ones are worked out, and although improvements in treatment may render profitable further extraction of gold, this may not offset exhaustion of placers and other deposits whose limits are necessarily being reached.

As shown above, in 1915 the output barely passed the figure set; and it has been falling very rapidly since.

The production of silver was 74,414,802 fine ounces in 1916 against 30,318,700 in 1880, and was the record output to date except the high mark of 74,961,075 in 1915. The increase in value of silver has been small as compared to that in quantity, the reason, of course, being the decrease in value per ounce. The large output of silver from the silver-gold ores of Tonopah and elsewhere, and from the vast increase in copper and lead mining and smelting in Arizona, Colorado, Idaho, Montana, Nevada, and Utah in recent years has much more than offset the decline of such conspicuous producers of the earlier days as the Comstock, Eureka, and earlier camps; but the lower price levels, as the metal has taken its natural place in the world's markets, without artificial stimulation, have prevented corresponding rises in value.

The domestic output of copper is recorded as far back as 1845, when 224,000 pounds were produced. The industry steadily expanded, until in 1880 we find an output of 60,480,000 pounds. Beginning with 1909 the production has been annually over 1,000,000,000 pounds and in 1916 reached 1,927,850,000 pounds (or nearly 2,000,000,000), which became a new record. In addition to continued output from the remarkable Lake mines and the later developed rich Butte veins, the domestic production has assumed new importance in recent years from the great low-grade disseminated deposits of Arizona, Utah, Nevada, and New Mexico, where applied geologic knowledge and new mining and milling methods have contributed notably to the world supremacy of the United States in copper output.

The production of lead, which was begun in colonial days and was carried on in a small way in the Central States as early as 1825, amounted to only 17,830 short tons in 1870 and to 95,725 tons from all classes of domestic ores in 1880, but broke all previous records with a total yield of 552,228 tons in 1916. The soft-lead ores of the Central States and the argentiferous ores of the Western States contribute the bulk of the yield.

The domestic production of zinc began in an experimental way in 1858 and was established in 1860 in both the Eastern and Central States. In 1873 the total output was 7,343 short tons, and it increased to 26,028 tons in 1880. The impressive record of 563,451 tons, valued at over $151,000,000, was reached in 1916. To the output of the historic New Jersey mines has been added that of the newly developed and important mines of eastern Tennessee. In the Central States Missouri and Oklahoma lead, and in the Western

States recent developments at Butte, Mont., Leadville, Colo., and elsewhere, have been noteworthy and have added largely to the known reserves.

Coal is foremost in importance, in both quantity and value of production among all mineral products—metallic and nonmetallic. Domestic mining began in Virginia, Ohio, and Pennsylvania as far back as the Revolutionary War, and the early records show that from 1807 to 1820 about 12,000 short tons of Pennsylvania anthracite were mined and about 3,000 short tons of bituminous coal. In 1880 the output had increased to 28,649,812 short tons of anthracite and 42,831,758 short tons of bituminous coal, and in 1916 the production was 78,195,083 long tons of Pennsylvania anthracite and 502,519,682 short tons of bituminous coal. This was the high record for bituminous to date, but the record for anthracite production was made in 1913, with 81,718,680 long tons. Notwithstanding the current enormous extraction, supplies of domestic coal have been assured for the national consumption for an indefinite time to come.

The needs of the country in fuel were first supplied from the forests and next from the coal mines. By 1859, however, petroleum was produced in Pennsylvania and in New York (although principally used at first in the making of kerosene for lighting), and the output reached 500,000 barrels, valued at $4,800,000, in 1860. By 1880 production had increased to 26,286,123 barrels, contributed by Pennsylvania, New York, Ohio, West Virginia, and California, and in 1916 all previous records were broken with the enormous output of 300,767,158 barrels. The production is now declining steadily in the older fields of Pennsylvania and New York, Ohio, West Virginia, Indiana, and Illinois, but remains high in California, and has increased notably in the newer fields of Kentucky and Tennessee, Kansas, Texas, Oklahoma, Wyoming, and Louisiana, although in Louisiana the record of 1915 was not reached in 1916. Petroleum and gas fields have not the life of coal fields, and the production can only be maintained by ceaseless exploration for new pools.

Natural gas has also supplemented earlier fuel and lighting resources, and from the first output, valued at $215,000 in 1882, it has reached the record production of $120,227,468 in 1916, principally from West Virginia, Pennsylvania, Ohio, and Oklahoma, in the order named.

The production of salt, which was among the half-dozen most important nonmetallic mineral products in 1880, increased to 6,362,906 short tons, valued at $13,645,947, in 1916 from the equivalent of 834,548 short tons, valued at $4,829,566, in 1880. Reserve supplies are vast in extent and production is only limited by demand.

Cement has climbed rapidly from a production of 2,072,943 barrels in 1880 to 92,363,335 barrels in 1916, which was only slightly below the record output of 92,949,102 barrels in 1913. In the earlier years the output was principally natural cement, as the production of Portland cement was only 42,000 barrels, valued at $126,000, in 1880. The natural cement industry reached its peak in 1899, with 9,868,179 barrels, since which time it has steadily declined. Puzzolan cement is first recorded for 1896 with an output of 12,265 barrels, and reached the high-water mark of 557,252 barrels in 1907, since which date it has also rapidly declined. Portland cement has so far outstripped all other kinds that it now constitutes practically the entire output.

The Lehigh district of eastern Pennsylvania and western New Jersey has been predominant, but the industry is now active in 26 States, and has developed a technique in which Americans may well take national pride.

The production of phosphate rock has grown from 211,377 long tons in 1880 to 1,982,385 tons in 1916, but this represented a considerable decline from the record output of 3,111,221 tons, valued at $11,796,231, in 1913. Phosphate mining began in the United States in 1867 in South Carolina, and for many years the domestic output was from this State and from Florida. In recent years vast reserves have been located and investigated in Utah, Wyoming, Idaho, and Montana, but the deposits have as yet hardly been scratched because of distance from centers of consumption.

Among the remarkable developments of domestic mineral products besides the 12 selected for comparative study of growth may be mentioned the aluminum, ferroalloys, and tungsten industries among the metals, and the asphalt, clay products, coke, gypsum, lime, mineral paints, gasoline, sand and gravel, and stone industries among nonmetals, whose value in 1916 ran into millions and which gave employment to large numbers of operatives.

## CONTINUED DEMANDS FOR INFORMATION DURING 1916.

In 1916, as in 1915, great activity characterized the mineral industries, and a further increased demand was made upon the United States Geological Survey for information respecting the available mineral supplies, the resources, and the prospects for greater production from the known mineral deposits. Rapid changes and new developments increased the work of the Survey in keeping in touch with the expanding industries; and the personnel, both scientific and clerical, was deflected from less war-important to more war-important investigations. Fortunately the studies of the Survey for many years had been largely upon an economic basis, and it was only necessary to bring up to date a vast fund of information already available and rearrange to some extent the form and scope of investigations of new material required. Therefore the various mineral resources reports were readily given fuller treatment or more elaborate discussion of previous data available, and a great deal of the information was made accessible to the public at large and to special investigators in published form; but a vast amount of additional data was again given out by correspondence and personal conferences to suit special needs. All demands upon the Survey were met and in many cases anticipated, and the initiative was taken to prepare against still greater demands. Routine work was necessarily held somewhat in abeyance, and publication of final results has frequently been delayed until long after the material had been compiled and put to use in other form.

## ACKNOWLEDGMENTS.

The United States Geological Survey is in touch with practically all mineral producers, smelters, refiners, and millmen in this country; with many manufacturers, exporters, and importers of mineral products; and with most operators of prospects, mines, quarries, and wells not producing but undergoing some development or merely

held by development work, and it is therefore impossible to make more than general acknowledgment for the vast amount of data contributed by them. Opportunity is taken here, however, to make this acknowledgment as best it may be made and to express grateful appreciation of the trouble taken by correspondents to make the reports of real value, and of the many courtesies shown to the Survey investigators The total number of these correspondents was well over 100,000 in 1916. Not only through the mails, but also by conferences and by field work of its specialists, the United States Geological Survey continues to keep in close touch with every branch of the mineral industries and the value of its reports is therefore unique.

Acknowledgment and appreciation is also due to the large number of Federal and State officials, bankers, merchants, transportation officials, and others who have generously given of their time to supply data required to complete the Survey investigations.

## ORGANIZATION.

The division of mineral resources of the United States Geological Survey, which is responsible for the annual reports "Mineral Resources of the United States" and related work, was divided during 1916 as in previous years into two sections—the "metals section," which prepares the reports of Part I, and the "nonmetals section," which prepares those of Part II, including fuels, structural materials other than metals, chemical materials, mineral fertilizers, and other nonmetallic products. Mr. Ernest F. Burchard was the geologist in charge of the nonmetals section, and the writer was charged with administrative supervision of the division, including cooperative relations with the State geologists, of the metals section, and of the western offices of the division.

These western offices were established primarily for the collection and compilation of data for the annual mines reports on the precious and base metals of the Western States, but they have been brought into such close touch with the mineral industries from the Rocky Mountains to the Pacific coast generally that they now cooperate with the Washington office on many branches of the mineral-resources work and also serve the mining industries and the public at large throughout the West as general bureaus of information and of distribution of Survey publications. The statisticians in charge (all of whom are technically trained along mineral lines) are Charles W. Henderson, 409 New Post Office Building, Denver, Colo.; Victor C. Heikes, 312 Post Office Building, Salt Lake City, Utah; and Charles G. Yale, 305 Customhouse, San Francisco. Mr. Henderson is author of the mines reports for Colorado, South Dakota, Wyoming, New Mexico, and Texas; Mr. Heikes (assisted by C. N. Gerry) is responsible for the mines reports for Utah, Nevada, Arizona, Montana, Idaho, and Washington; and Mr. Yale contributes the mines reports for California and Oregon, and is coauthor also of the reports on borax and magnesite for the entire country.

The division of mineral resources works in close cooperation with other divisions of the geologic branch, and most of the reports on mineral resources have been written in recent years by geologists working in more than one division, who specialize on the subjects treated by them. The advantage of this arrangement is to utilize

the full resources of the Survey in the service of specialists familiar with the occurrence, treatment, and use of the mineral substances covered.

The authors of the reports for 1916 were as follows:

General:
H. D. McCaskey—Mineral production of the United States (introduction).
Martha B. Clark—Mineral production of the United States (summary).

Metals:
E. S. Bastin—Antimony.
A. H. Brooks—Gold, silver, copper, and lead in Alaska (mines reports).
E. F. Burchard—Iron ore, pig iron, and steel.
B. S. Butler—Copper; silver and copper in Michigan (mines reports).
J. S. Diller—Chromite.
J. P. Dunlop—Silver, copper, lead, and zinc in Central States, except Michigan (mines reports); secondary metals; gold and silver (with H. D. McCaskey).
C. N. Gerry—Gold, silver, copper, lead, and zinc in Idaho and Washington (mines reports).
V. C. Heikes—Gold, silver, copper, lead, and zinc in Arizona, Montana, Nevada, and Utah (mines reports).
C. W. Henderson—Gold, silver, copper, lead, and zinc in Colorado, New Mexico, South Dakota, Texas, and Wyoming (mines reports).
F. L. Hess—Cobalt, nickel, molybdenum, radium, tantalum, titanium, tungsten, uranium and vanadium.
D. F. Hewett—Manganese and manganiferous ores.
J. M. Hill—Bauxite and aluminum; gold, silver, copper, lead, and zinc in Eastern States (mines reports); platinum and allied metals.
Adolph Knopf—Tin.
H. D. McCaskey—Gold and silver (with J. P. Dunlop); quicksilver.
C. E. Siebenthal—Cadmium; lead; zinc.
J. B. Umpleby—Arsenic, bismuth, selenium, and tellurium.
C. G. Yale—Gold, silver, copper, lead, and zinc in California and Oregon (mines reports).

Nonmetals:
E. F. Burchard—Cement; fluorspar and cryolite.
A. A. Chambers—Mineral waters (with A. J. Ellis).
J. S. Diller—Asbestos; talc and soapstone.
A. J. Ellis—Mineral waters (with A. A. Chambers).
H. G. Ferguson—Graphite.
H. S. Gale—Borax (with C. G. Yale); magnesite (with C. G. Yale); potash salts.
J. M. Hill—Barytes and barium products; strontium.
F. J. Katz—Abrasive materials; feldspar; silica.
C. E. Lesher—Artificial gas; coal; coke; fuel briquetting.
G. F. Loughlin—Lime; slate; stone.
Jefferson Middleton—Clay-working industry; fuller's earth; sand-lime brick.
J. D. Northrop—Asphalt, related bitumens, and bituminous rock; natural gas; petroleum.
W. T. Schaller—Gems and precious stones; lithium; mica; thorium; zirconium and rare-earth minerals.
P. S. Smith—Pyrite, sulphur, and sulphuric acid.
R. W. Stone—Gypsum; phosphate rock; salt, bromine, and calcium chloride; sand and gravel.
J. S. Turp—Peat.
C. G. Yale—Borax (with H. S. Gale); magnesite (with H. S. Gale).

Once more the writer makes acknowledgment of the work done by his colleagues in the preparation of the reports and of the loyal and efficient service given by the statistical, clerical, and stenographic assistants. The group of specialists includes many of the ablest economic geologists, chemists, and engineers of the Survey, and the contributions they make are of special value because of their training in field and office which especially fits them for the well-rounded study of their respective subjects. Many of the clerical staff have now been connected so long and in such a responsible way with the collection and tabulation of statistics assigned to them that they

are most creditably identified with their subjects. Their intelligent scrutiny and criticism of the returns and skillful interpretation of the results are invaluable in saving the time of the specialists, and their conscientious devotion to duty has maintained the high standards set for accuracy and completeness of the reports.

### COOPERATION WITH STATE GEOLOGICAL SURVEYS.

In the collection of data for the mineral resources reports the United States Geological Survey has had since 1910 the cooperation of many of the corresponding State organizations. The statistics obtained by pooling efforts and field and office facilities are jointly checked and are the official figures of both State and Federal surveys. The objects aimed at in cooperation are mainly the avoidance of duplication of effort on the part of both compilers and operators and of divergent sets of figures bearing the official stamp.

Cordial acknowledgment for helpful and most satisfactory cooperation is made to the following State officials for the statistical campaign for 1916:

Alabama.....Dr. Eugene A. Smith, State geologist, University.
Florida.....Dr. E. H. Sellards, State geologist, Tallahassee.
Illinois.....Mr. Frank W. DeWolf, director, Urbana.
Iowa.....Prof. George F. Kay, director, Iowa City.
Maryland.....Dr. William B. Clark, State geologist, Baltimore.
Michigan.....Mr. R. C. Allen, director, Lansing.
Minnesota.....Dr. W. H. Emmons, director, Minneapolis.
Missouri.....Dr. H. A. Buehler, director, Rolla.
New Jersey.....Dr. Henry B. Kümmel, State geologist, Trenton.
New York.....Dr. John M. Clarke, State geologist, Albany.
North Carolina.....Dr. Joseph Hyde Pratt, State geologist, Chapel Hill.
Oregon.....Prof. H. M. Parks, director, Corvallis.
Virginia.....Dr. Thomas L. Watson, director, Charlottesville.
Washington.....Prof. Henry Landes, State geologist, Seattle.
Wisconsin.....Mr. W. O. Hotchkiss, State geologist, Madison.

For the statistical campaign of 1917 the State geologist of Georgia, Dr. S. W. McCallie, and the State geologist of Pennsylvania, Mr. Richard R. Hice, have renewed cooperation with the United States Geological Survey.

Informal cooperation has been had for some time past between the San Francisco and Washington offices of the Federal Survey on the one hand, and the California State Mining Bureau under Mr. F. McN. Hamilton, State mineralogist, assisted by Mr. Walter N. Bradley and Mr. E. S. Boalich on the other; and a most cordial and generous assistance has always been given by this efficient California administration.

Many of the State mine inspectors also ably and cordially cooperated with the Federal Survey, especially with regard to production of fuels.

# SUMMARY.

By MARTHA B. CLARK.

## REVIEW BY PRODUCTS.

### GENERAL REMARKS.

The unit of measurement used by the Geological Survey for each mineral product in the reports on the mineral resources is that common to the industry concerned, and the variation in these units makes it impracticable, if not impossible, to combine and compare the different minerals except in value.

In 1899, for the first time, the total value of the mineral production of the United States exceeded $1,000,000,000; in 1905 and 1906 it was more than $1,500,000,000; and in 1907 it exceeded $2,000,000,000. In 1908 the results of the financial depression of the later part of 1907 became apparent in the decrease in value of the mineral output, which declined for the year to about $1,595,000,000. In 1909 the general recovery in business carried the value of mineral production up to nearly $1,887,000,000, and continued favorable business conditions in 1910 raised the value to more than $1,991,000,000—almost to the high level of 1907. In 1911 there was a sharp decline in pig iron that brought the total value for the year down to about $1,927,000,000, but the general swing of business in 1912 carried the value of mineral production above $2,245,000,000, and further advance was recorded in 1913, when the total was more than $2,441,000,000. In 1914 the value of the mineral production of the United States declined to about $2,118,000,000, but in 1915 it increased more than $279,000,000, reaching nearly $2,398,000,000, and falling short of the record value of 1913 by less than 2 per cent.

In 1916, owing to the demand for increased production of war minerals and to their greater value, especially the metals, the total value of the mineral production was the greatest in the history of the country (nearly $3,514,000,000), increasing $1,116,000,000, or 47 per cent, over the $2,398,000,000 recorded for 1915, and exceeding the former record year (1913) by more than $1,000,000,000. Practically all the minerals shared in this increase, gold being the only one of the more important products that showed a decrease in value, though silver and anthracite showed decreases in quantity, but increases in value.

The metals established a new record in 1916, exceeding for the first time $1,000,000,000 and approximating a total of $1,621,000,000. Pig iron and copper contributed more than 78 per cent of the total increase of $629,000,000, but large gains were made in zinc, lead, aluminum, ferroalloys, and tungsten ores. As compared with the figures for 1915, the metallic products increased 63 per cent.

The total value of the nonmetallic products increased more than $320,000,000 over the value for 1913, the year of next highest output, the figures for 1916 being $1,878,000,000 as compared with

$1,558,000,000 for 1913. As compared with 1915, the value of the nonmetallic products for 1916 showed an increase of $480,000,000, or 34 per cent. Coal and petroleum contributed 69 per cent of the increase shown in the nonmetallic products.

As heretofore, coal and iron are the most valuable of our mineral products. The value of coal in 1916 was $867,126,000 and that of iron (pig iron being the basis of valuation) $663,478,000. The fuels—coal, natural gas, and petroleum—increased from $967,500,000 in 1915 to $1,318,300,000 in 1916, a gain of about $350,800,000, or 36 per cent.

The unspecified products (metallic and nonmetallic), valued in 1916 at $15,000,000, and including the value of antimony other than content of antimonial lead, bismuth, cadmium sulphide, chats or tailings from Missouri zinc mines, a considerable production of diatomaceous earth for special uses, ilmenite, iron ore sold for magnets and paint, lithium minerals, lithographic stone, magnesium, marls, molybdenum, pebbles for grinding, selenium, silica sand and sandstone (finely ground), strontium, sulphur, and volcanic ash used for railroad ballast, and an estimate of the value of miscellaneous mineral products not collected annually by the Survey, bring the total value of the mineral production for 1916 up to $3,513,934,196.

The arrangement of the minerals alphabetically in the metallic and nonmetallic groups will, it is believed, prove to be the most convenient form for reference. It is the plan of the Survey to publish the figures in detail for all years beginning with 1880 in Mineral Resources every fifth year. The detailed figures for the early years appeared in the report for 1915 and will next be shown in the report for 1920. For the intervening years the mineral chart (showing 10 years in detail and totals for all years) will be inclosed in a pocket, as has been the custom in the past, and the chart showing production and value of mineral products through 1916 will be found in the pocket in this report.

The imports cited in this summary are imports "for consumption" (so far as such figures are available) for the calendar year and may or may not be identical with "general" imports. Merchandise brought into the country late in December, for example, may be entered for consumption or it may be put into a warehouse and not withdrawn for consumption until the following calendar year. It is then credited "for consumption" to the year of its withdrawal from the warehouse.

The following summary gives the production and its value, the imports, and the exports of each mineral product for the last five years. The statistics of imports and exports were compiled by James A. Dorsey.

## METALLIC PRODUCTS.

*Aluminum.*—The value of primary aluminum produced in the United States in 1916 was $33,900,000 compared with $16,280,000 in 1915, $10,080,000 in 1914, $9,450,000 in 1913, and $7,400,000 in 1912. The imports of aluminum salts for consumption were valued at $68,660 in 1916, $34,320 in 1915, $73,028 in 1914, $66,549 in 1913, and $84,606 in 1912. The exports of aluminum and of the manufactures of aluminum of domestic production were valued at $15,417,134 in 1916, $3,682,117 in 1915, $1,546,510 in 1914, $966,094 in 1913, and $1,347,621 in 1912.

*Antimonial lead.*—The production of antimonial lead in 1916 was 24,038 short tons, valued at $4,483,582, against 23,224 tons, valued at $3,665,736, in 1915; 16,667 tons, valued at $1,572,167, in 1914; 16,665 tons, valued at $1,591,854, in 1913; and 13,552 tons, valued at $1,311,348, in 1912.

*Antimony.*—The antimony contained in antimony ore and in antimonial lead amounted in 1915 to 5,364 short tons, valued at $2,373,760, compared with 2,705 tons, valued at $566,490, in 1914; 2,508 tons, valued at $429,363, in 1913; and 1,949 tons, valued at $332,889, in 1912. Corresponding figures for 1916 are not available. The imports of antimony (metal, regulus, and ore) for consumption were valued at $4,620,847 in 1916, $2,992,955 in 1915, $811,765 in 1914, $936,361 in 1913, and $859,917 in 1912. Imports of oxide and salts of antimony were valued at $109,832 in 1916, $132,193 in 1915, $315,001 in 1914, $117,169 in 1913, and $81,077 in 1912.

*Bauxite.*—In 1916 the production of bauxite was 425,100 long tons, valued at the mines at $2,296,400, compared with 297,041 tons, valued at $1,514,834, in 1915; 219,318 tons, valued at $1,069,194, in 1914; 210,241 tons, valued at $997,698, in 1913; and 159,865 tons, valued at $768,932, in 1912. The imports for consumption were 30 long tons, valued at $87 in 1916, against 3,420 tons, valued at $17,107, in 1915; 24,844 tons, valued at $96,500, in 1914; 21,456 tons, valued at $85,746, in 1913; and 26,214 tons, valued at $95,431, in 1912.

*Bismuth.*—A production of bismuth (saved as a by-product in electrolytic refining of lead) was reported for 1916 as for 1915, but the Survey is not at liberty to publish the figures. The production for 1914 was 220,000 pounds, valued at $426,000, compared with 157,300 pounds, valued at $273,650, in 1913. The imports for consumption were valued at $195,975 in 1916, $108,288 in 1915, $165,208 in 1914, $213,257 in 1913, and $316,440 in 1912.

*Cadmium.*—The production of metallic cadmium in 1916 was 135,212 pounds, valued at $210,931, compared with 91,415 pounds, valued at $108,443, in 1915; 91,409 pounds valued at $81,205, in 1914; 54,198 pounds, $41,838, in 1913; and 52,508 pounds, $39,875, in 1912. In addition to the metallic cadmium, the production of cadmium sulphide has been as follows: 22,176 pounds, $27,942, in 1916; 10,624 pounds, $12,057, in 1915; 22,723 pounds, $20,241, in 1914; 17,302 pounds, $12,136, in 1913; and 8,998 pounds, $6,400, in 1912. The imports of cadmium for consumption were valued at $284 in 1915, $368 in 1914, $1,232 in 1913, and $3,764, in 1912. No imports were reported in 1916.

*Chromic iron ore.*—The quantity of chromic iron ore marketed in 1916 was 47,035 long tons, valued at $726,243, compared with 3,281 tons, valued at $36,744, in 1915; 591 tons, valued at $8,715, in 1914; 255 tons, valued at $2,854, in 1913; and 201 tons, valued at $2,753, in 1912. The imports of chromic iron ore for consumption were 115,945 long tons, valued at $1,548,402, in 1916; against 76,455 tons, valued at $780,061, in 1915; 80,736 tons, valued at $695,645, in 1914; 65,180 tons, valued at $622,821, in 1913; and 53,929 tons, valued at $499,818, in 1912. The imports of chromic acid and chromates of potash were valued at $75 in 1916; $3,657 in 1915; $3,972 in 1914; $2,919, in 1913; and $4,461, in 1912.

*Copper.*—The production of copper in 1916 from domestic ores was 1,927,850,548 pounds, valued at New York City at $474,288,000, against 1,388,009,527 pounds, valued at $242,902,000, in 1915; 1,150,137,192 pounds, valued at $152,968,000, in 1914; 1,224,484,098 pounds, valued at $189,795,035, in 1913; and 1,243,268,720 pounds, valued at $205,139,338, in 1912. The imports for consumption were valued at $94,469,458 in 1916, against $44,394,592 in 1915, $39,491,973 in 1914, and $57,639,490 in 1913; and the exports in 1916 at $206,163,241, against $117,703,941 in 1915, $117,633,145 in 1914; and $146,327,621 in 1913.

*Ferroalloys.*—In the report on iron for 1911 the United States Geological Survey undertook for the first time to present the statistics of production of ferroalloys separately from those of pig iron, with which they had been included. As reported, the quantity of ferroalloys marketed in 1916 was 589,738 long tons, valued at the furnaces at $50,281,692, compared with 388,644 tons, valued at $17,450,385, in 1915; 255,524 tons, valued at $9,350,245, in 1914; 296,207 tons, valued at $13,015,362, in 1913; and 328,685 tons, valued at $12,223,776, in 1912. Part of the output is derived from foreign ores. These quantities fall short of the total production of the United States, as the output of certain electrically produced ferroalloys is not available for publication by the Geological Survey. The Bureau of Foreign and Domestic Commerce reports the following values of imports of ferroalloys for consumption in 1913, 1914, 1915, and 1916: Chrome and ferrochrome, $51,415 in 1913, $21,553 in 1914, $1,662 in 1915, and $1,998, in 1916; ferrophosphorus, none imported in 1913, $1,136 in 1914, $617 in 1915, and none imported in 1916; ferrosilicon, $449,871, $341,925, $311,219, and $384,384; ferromanganese, $5,682,915, $3,619,607, $3,333,699, and $9,240,528; molybdenum and ferromolybdenum, $15,939, $59, $203, and none imported in 1916; spiegeleisen, $2,173, $71,147, $5,110, and none imported in 1916; titanium and ferrotitanium, $7,198, $8,356, none in 1915, and $8,126 in 1916; tungsten and ferrotungsten, $835,212, $222,447, $9,588, and $157,711—a total of $7,044,723 in 1913, $4,286,230 in 1914, $3,662,098 in 1915, and $9,792,747 in 1916.

*Gold.*—The production of gold in 1916 was 4,479,056 fine ounces, valued at $92,590,300, compared with 4,887,602 ounces, valued at $101,035,700, in 1915; 4,572,976 ounces, valued at $94,531,800, in 1914; 4,299,783 ounces, valued at $88,884,400, in 1913; and 4,520,717 ounces, valued at $93,451,500, in 1912.

*Iron (ore and pig).*—The quantity of iron ore marketed in 1916 amounted to 77,870,553 long tons, valued at the mines at $181,902,277, compared with 55,493,100 tons, valued at $101,288,984, in 1915; 39,714,280 tons, valued at $71,905,079, in 1914; 59,643,098 tons, valued at $130,905,558, in 1913; and 57,017,614 tons, valued at $107,050,153, in 1912. The imports of iron ore for consumption were valued at $4,566,514 in 1916, $4,181,645 in 1915, $4,482,242 in 1914, and $8,332,777 in 1913; and the exports at $3,702,496 in 1916, $2,181,629 in 1915, $1,794,193 in 1914, $3,513,419 in 1913, and $3,537,289 in 1912.

The quantity of pig iron marketed in 1916 was 39,126,324 long tons, valued at the furnaces at $663,478,118, compared with 30,384,486 tons, valued at $401,409,604, in 1915; 22,263,263 tons, valued at $298,777,429, in 1914; 30,388,935 tons, valued at $458,342,345,

in 1913; and 30,180,969 tons, valued at $420,563,388, in 1912. The exports of pig iron in 1916, 1915, 1914, and 1913 were 607,236 long tons, valued at $15,381,431; 224,509 tons, valued at $3,667,167; 114,423 tons, valued at $1,638,102; and 277,648 tons, valued at $4,026,306, respectively.

*Lead.*—The production of refined lead from domestic ores in 1916 was 552,228 short tons, valued at New York City at $76,207,000, compared with 507,026 tons, valued at $47,660,000, in 1915; 512,794 tons, valued at $39,998,000, in 1914; 411,878 tons, valued at $36,245,264, in 1913; and 392,517 tons, valued at $35,326,530, in 1912. The imports of lead for consumption were valued at $1,014,959 in 1916, against $772,955 in 1915, $504,978 in 1914, $572,980 in 1913, and $605,551 in 1912; and the exports of lead at $16,016,481 in 1916, $10,063,352 in 1915, $5,519,908 in 1914, and $738,135 in 1913.

*Magnesium.*—So far as is known magnesium had not been produced on a commercial scale in the United States until 1915, though experiments looking toward that end had been performed by various firms at different times, and especially since the beginning of the European war in 1914. The total production for 1916 was 75,400 pounds, valued at $311,462, compared with 87,500 pounds, valued at about $440,000, in 1915.

*Manganese ore.*—The quantity of manganese ore (containing 40 per cent or more manganese) marketed in 1916 was 26,997 long tons, valued at the mines at $627,417, compared with 8,708 tons, valued at $108,049, in 1915; 2,635 tons, valued at $27,377, in 1914; 4,048 tons, valued at $40,480, in 1913; and 1,664 tons, valued at $15,723, in 1912. The imports of manganese ore for consumption were 569,569 long tons, valued at $8,640,065, against 320,778 tons, valued at $2,655,980, in 1915; 283,294 tons, valued at $2,024,120, in 1914; 345,090 tons, valued at $2,029,680, in 1913; and 300,661 tons, valued at $1,769,184, in 1912.

*Manganiferous ore.*—In 1916 the quantity of manganiferous ore (containing less than 40 per cent manganese, but not less than 5 per cent) marketed was 548,803 long tons, valued at the mines at $2,005,491, against 196,640 tons, valued at $822,216, in 1915; 98,265 tons, valued at $218,497, in 1914; 59,403 tons, valued at $25,124, in 1913; and 51,517 tons, valued at $19,942, in 1912.

*Molybdenum.*—The production of molybdenum in 1916 was valued at about $205,000, compared with about $115,000 in 1915. There was also a small production in 1914, but none is known to have been produced in 1913. Imports of molybdenum and ferromolybdenum were valued at $203 in 1915, $59 in 1914, $15,939 in 1913, and $4,670 in 1912. There were no imports in 1916.

*Nickel.*—Metallic nickel and nickel content of nickel salts, amounting to 918 short tons, valued at $671,192, was saved as a by-product in electrolytic refining of copper in 1916, compared with 822 tons, valued at $538,222, in 1915; 423 tons, valued at $313,000, in 1914; and 241 tons, valued at $79,393, in 1913. The imports of nickel for consumption were valued at $9,904,236 in 1916, against $7,629,686 in 1915, $5,028,818 in 1914, $6,600,755 in 1913, and $5,758,967 in 1912. The exports were valued at $12,952,493 in 1916, $10,128,514 in 1915, $9,455,528 in 1914, $9,686,794 in 1913, and $8,515,332 in 1912.

*Platinum and allied metals.*—The production of refined platinum and allied metals in 1916 was 28,088 fine ounces, valued at New York City at $2,301,762, compared with 8,665 ounces, valued at $478,688, in 1915; 6,324 ounces, valued at $280,885, in 1914; 1,034 ounces, valued at $46,530, in 1913; and 1,005 ounces, valued at $45,778, in 1912. The imports of platinum (manufactured and unmanufactured including platinum ores) for consumption were valued at $3,159,959 in 1916, $2,415,275 in 1915, $2,981,013 in 1914, $5,040,210 in 1913, and $4,503,682 in 1912. In 1916 the imports of the platinum-group metals (other than platinum) for consumption were: Iridium, $250,705; osmiridium, $17,241; osmium, none; palladium, $282,910; rhodium, none; and ruthenium, none—a total of $550,856. In 1915: Iridium, $243,266; osmiridium, $5,737; osmium, $787; palladium, $103,623; rhodium, none; and ruthenium, none—a total of $353,413. In 1914: Iridium, $112,430; osmiridium, $84,363; osmium, none; palladium, $69,547; rhodium, $1,905; and ruthenium, $576—a total of $268,821. In 1913 these imports were: Iridium, $295,864; osmiridium, $11,872; osmium, $42,924; palladium, $364,738; rhodium, $3,668; and ruthenium, none—a total of $719,066.

*Quicksilver.*—The production of quicksilver in 1916 amounted to 29,932 flasks (75 pounds net), valued at San Francisco at $3,768,139, against 21,033 flasks, valued at $1,804,631, in 1915; 16,548 flasks, valued at $811,680, in 1914; 20,213 flasks, valued at $813,171, in 1913; and 25,064 flasks, valued at $1,053,941, in 1912. The imports for consumption were valued at $515,919 in 1916, $282,752 in 1915, $271,984 in 1914, $75,361 in 1913, and $39,920 in 1912; and the exports at $670,475 in 1916, $225,509 in 1915, $70,753 in 1914, $43,574 in 1913, and $13,360 in 1912.

*Selenium.*—The Survey is not at liberty to publish the production of selenium in 1916 and 1915, which was all saved as a by-product in electrolytic refining of copper. The output for 1914 was 22,867 pounds, valued at $34,277; for 1913 it was 29,097 pounds, valued at about $46,900.

*Silver.*—The production of silver in 1916 was 74,414,802 fine ounces, with an estimated commercial value of $48,953,000, against 74,961,075 ounces, valued at $37,397,300, in 1915; 72,455,100 ounces, valued at $40,067,700, in 1914; 66,801,500 ounces, valued at $40,348,100, in 1913; and 63,766,800 ounces, valued at $39,197,500, in 1912.

*Tantalum minerals.*—No production of tantalum minerals was reported for 1912, 1913, 1914, 1915, or 1916. Very small quantities of tantalum ore (columbite) were reported mined in 1911, 1910, and 1909, but none was reported marketed. The imports of tantalum for consumption were valued at $2,000 in 1916, $163 in 1915, none reported in 1914, $24 in 1913, and $58 in 1912.

*Tellurium.*—A small quantity of tellurium was obtained from copper anode muds in 1913. The quantity saved in 1914, 1915, and 1916 was inconsiderable.

*Tin.*—In 1916 tin ore (equivalent to 140 short tons of metallic tin), valued at $122,000, was reported, against the equivalent of 102 tons of metallic tin, valued at $78,846, in 1915; 104 tons of metallic tin, valued at $66,560, in 1914; 120 tons of 60 per cent ore in 1913, valued at $46,699; and 147 tons of 60 per cent ore in 1912, valued at $124,800. The imports of tin for consumption were valued at $51,802,232 in

1916, $38,736,909 in 1915, $32,881,619, in 1914, $46,927,213 in 1913, and $50,372,478 in 1912.

*Titanium minerals.*—In 1916 the Virginia mines reported 110 short tons of rutile, valued at $16,500, and 95 tons of ilmenite, valued at $1,900, against 250 tons of rutile, valued at $27,500, in 1915; 94 tons of rutile, valued at $11,280, and 89 tons of ilmenite, valued at $4,895, in 1914; 305 tons of rutile, valued at $49,000, in 1913; and 275 tons of rutile, valued at $27,500, in 1912. Imports of titanium and ferrotitanium were valued at $8,126 in 1916, $8,356 in 1914, $7,198 in 1913, $7,631 in 1912, but none were reported in 1915.

*Tungsten ore.*—The production of tungsten ore (60 per cent concentrates) in 1916 was 5,923 short tons, valued at $12,074,000, against 2,332 tons, valued at $4,100,000, in 1915; 990 tons, valued at $435,000, in 1914; 1,537 tons, $672,118, in 1913; and 1,330 tons, $502,158, in 1912. The imports of tungsten ore for consumption were valued at $7,353,691 in 1916, $1,044,986 in 1915, $139,687 in 1914, and $213,122 in 1913. Tungsten and ferrotungsten imported were valued at $157,711 in 1916, $9,588 in 1915, $222,447 in 1914, $835,212 in 1913, and $323,872 in 1912.

*Uranium and vanadium minerals.*—The production of uranium and vanadium minerals in 1916 was valued at $500,000, compared with $693,750 in 1915, $941,300 in 1914, and $609,361 in 1913. No imports of ferrovanadium were reported for 1912, 1913, 1914, 1915, or 1916. Imports of uranium salts and oxide, including some radium salts, were valued at $5,065 in 1916, $17,288 in 1915, $63,055 in 1914, and $34,319 in 1913.

*Zinc.*—The production of zinc in 1916 from domestic ores was 563,451 short tons, $151,005,000 being the sales value, against 458,135 tons in 1915 with a sales value of $113,617,000; 343,418 tons, valued at St. Louis at $35,029,000, in 1914; 337,252 tons, $37,772,224, in 1913; and 323,907 tons, $44,699,166, in 1912. The imports of zinc ore and manufactures of zinc for consumption were valued at $4,184,745 in 1916, $1,585,494 in 1915, $425,205 in 1914, $1,079,994 in 1913, and $2,114,435 in 1912. The exports of domestic zinc ore and domestic manufactures of zinc were valued at $51,900,069 in 1916, $32,253,001 in 1915, $9,381,050 in 1914, $1,735,099 in 1913, and $1,846,301 in 1912.

## NONMETALLIC PRODUCTS.

*Arsenious oxide.*—The production of arsenious oxide (white arsenic) in 1916 amounted to 5,986 short tons, valued at $555,187, against 5,498 tons, valued at $302,116, in 1915; 4,670 tons, valued at $313,147, in 1914; 2,513 tons, valued at $159,236, in 1913; and 3,141 tons, valued at $190,757, in 1912. The imports of "arsenic or arsenious acid" and "arsenic sulphide or orpiment" for consumption were valued at $232,694 in 1916, $267,776 in 1915, $273,713 in 1914, $410,446 in 1913, and $428,741 in 1912.

*Asbestos.*—The production of asbestos in 1916 was 1,479 short tons, valued at $448,214, against 1,731 tons, valued at $76,952, in 1915; 1,247 tons, valued at $18,965, in 1914; 1,100 tons, valued at $11,000, in 1913; and 4,403 tons, valued at $87,959, in 1912. The imports of asbestos (manufactured and unmanufactured) for consumption were valued at $3,441,388 in 1916, $2,121,002 in 1915, $1,779,223 in 1914, $2,307,666 in 1913, and $1,820,528 in 1912.

*Asphalt.*—Under the term "asphalt" are included the various bitumens or hydrocarbon minerals not discussed elsewhere under petroleum. The production in 1916 was 786,811 short tons, valued at $7,102,132, against 740,254 tons, valued at $5,242,073, in 1915; 440,571 tons, valued at $3,659,092, in 1914; 529,190 tons, valued at $5,282,370, in 1913; and 449,510 tons, valued at $4,620,731, in 1912. The imports of asphalt for consumption were valued at $734,712 in 1916, $680,357 in 1915, $675,618 in 1914, $910,611 in 1913, and $920,145 in 1912. The exports for the years 1916, 1915, 1914, and 1913 were valued at $1,254,664, $1,174,637, $1,247,020, and $1,679,411, respectively.

*Barytes.*—The production of crude barytes in 1916 was 221,952 short tons, valued at $1,011,232, compared with 108,547 tons, valued at $381,032, in 1915; 52,747 tons, valued at $155,647, in 1914; 45,298 tons, valued at $156,275, in 1913; and 37,478 tons, valued at $153,313, in 1912. The imports of barytes (manufactured and unmanufactured) for consumption were valued at $2,317 in 1916, $15,613 in 1915, $77,265 in 1914, $99,564 in 1913, and $79,315 in 1912. The imports of barium compounds were valued at $459,841 in 1916, $438,826 in 1915, $778,804 in 1914, $582,605 in 1913, and $556,168 in 1912.

*Borax.*—The production of crude borax in 1916 was 103,525 short tons, valued at $2,409,459, against 67,003 tons, valued at $1,677,099, in 1915; 62,400 tons, valued at $1,464,400, in 1914; 58,051 tons, valued at $1,491,530, in 1913; and 42,315 tons, valued at $1,127,813, in 1912. The imports of borax and borates for consumption were valued at $20,043 in 1916, $21,281 in 1915, $19,412 in 1914, $18,534 in 1913, and $11,249 in 1912.

*Bromine.*—The production of bromine in 1916 amounted to 728,520 pounds, valued at $951,932, against 855,857 pounds, valued at $856,307, in 1915; 576,991 pounds, valued at $203,094, in 1914; 572,400 pounds, valued at $115,436, in 1913; and 647,200 pounds, valued at $145,805, in 1912.

*Calcium chloride.*—The production of calcium chloride in 1916 was 26,062 short tons, valued at $216,729, against 20,535 tons, valued at $130,830, in 1915; 19,403 tons, valued at $121,766, in 1914; 19,611 tons, valued at $130,030, in 1913; and 18,550 tons, valued at $117,272, in 1912.

*Cement.*—The total quantity of the principal hydraulic cements in the United States marketed in 1916 was 95,394,433 barrels (376 pounds net), valued at the mills at $104,689,090, compared with 87,685,222 barrels, valued at $75,155,102 in 1915; 87,257,552 barrels, valued at $80,533,203, in 1914; 89,541,348 barrels, valued at $89,550,527, in 1913; and 85,925,651 barrels, valued at $69,554,385, in 1912. The quantity of Portland cement marketed in 1916 was 94,552,296 barrels, valued at $104,258,216, compared with 86,891,681 barrels, valued at $74,756,674, in 1915; 86,437,956 barrels, valued at $80,118,475, in 1914; 88,689,377 barrels, valued at $89,106,975, in 1913; and 85,012,556 barrels, valued at $69,109,800, in 1912. As there was only one producer of puzzolan cement in 1916, the figures for that year are combined with those for natural cement, the total quantity produced being 842,137 barrels, valued at $430,874. The production of natural cement in 1915 was 750,863 barrels, valued at $358,627, compared with 751,285 barrels, valued at $351,370, in 1914;

744,658 barrels, valued at $345,889, in 1913; and 821,231 barrels, valued at $367,222, in 1912. The production of puzzolan cement in 1915 amounted to 42,678 barrels, valued at $39,801, against 68,311 barrels, valued at $63,358, in 1914; 107,313 barrels, valued at $97,663, in 1913; and 91,864 barrels, valued at $77,363, in 1912. The imports of hydraulic cements for consumption were valued at $4,942 in 1916, $57,174 in 1915, $194,053 in 1914, $139,416 in 1913, and $93,558 in 1912; and the exports at $3,828,231 in 1916, $3,361,451 in 1915, $3,088,809 in 1914, $4,270,666 in 1913, and $6,160,341 in 1912.

*Clay products and raw clay.*—The value of all clay products in 1916 was $207,260,091, compared with $163,120,232 in 1915, $164,986,983 in 1914, $181,289,132 in 1913, and $172,811,275 in 1912. The imports of brick and tile, etc., for consumption were valued at $165,080 in 1916, against $171,801 in 1915, $207,644 in 1914, $276,677 in 1913, and $215,379 in 1912; and the exports at $2,999,036 in 1916, $1,531,210 in 1915, $1,917,068 in 1914, $2,662,568 in 1913, and $2,105,216 in 1912. The pottery products were valued at $48,217,242 in 1916, $37,325,388 in 1915, $35,398,161 in 1914, $37,992,375 in 1913, and $36,504,164 in 1912. The imports of pottery for consumption amounted to $5,600,585 in 1916, against $6,628,086 in 1915, $8,398,593 in 1914, $10,217,078 in 1913, and $9,621,822 in 1912; and the exports of pottery were valued at $1,076,572 in 1916, $563,452 in 1915, $526,902 in 1914, $559,331 in 1913, and $1,177,784 in 1912.

Clay mined and sold as unmanufactured clay amounted in 1916 to 2,932,590 short tons, valued at $5,751,774, against 2,362,954 tons, valued at $3,971,941, in 1915; 2,209,860 tons, valued at $3,756,568, in 1914; and 2,647,989 tons, valued at $4,180,459, in 1913. The imports of kaolin or china clay for consumption were valued at $1,326,684 in 1916, $1,152,778 in 1915, $1,927,425 in 1914, $1,623,993 in 1913, and $1,629,105 in 1912. The imports of other clays for consumption amounted in 1916 to $177,549, against $165,369 in 1915, $359,993 in 1914, and $382,782 in 1913.

*Coal.*—In 1916 the output of coal was 590,098,175 short tons, valued at the mines at $867,125,638, compared with 531,619,487 tons, valued at $686,691,186, in 1915; 513,525,477 tons, valued at $681,490,643, in 1914; 569,960,219 tons, valued at $760,416,079, in 1913; and 534,466,580 tons, valued at $695,606,071, in 1912.

The production of bituminous coal (which includes all coals except anthracite mined in Pennsylvania) amounted in 1916 to 502,519,682 short tons, valued at the mines at $665,116,077, compared with 442,624,426 tons, valued at $502,037,688, in 1915; 422,703,970 tons, valued at $493,309,244, in 1914; 478,435,297 tons, valued at $565,234,952, in 1913; and 450,104,982 tons valued at $517,983,445 in 1912. The imports of bituminous coal for consumption were valued at $4,736,631 in 1916, $4,410,772 in 1915, $3,902,881 in 1914, $3,853,930 in 1913, and $4,509,066 in 1912. The exports were valued at $45,828,092 (not including bunker coal valued at $27,491,822) in 1916; $42,817,341 (not including bunker coal valued at $25,192,956) in 1915; $34,104,903 (not including bunker coal valued at $24,145,735) in 1914; and at $45,449,664 (not including bunker coal valued at $25,036,272) in 1913.

The output of Pennsylvania anthracite in 1916 was 78,195,083 long tons, valued at the mines at $202,009,561, compared with 79,459,876 tons, valued at $184,653,498, in 1915; 81,090,631 tons,

valued at $188,181,399, in 1914; 81,718,680 tons, valued at $195,181,127, in 1913; and 75,322,855 tons, valued at $177,622,626, in 1912. The imports of anthracite for consumption were valued at $7,202 in 1916, $4,224 in 1915, $25,380 in 1914, $5,620 in 1913, and $8,329 in 1912; and the exports at $22,470,147 in 1916, $18,429,255 in 1915, $20,211,072 in 1914, and $21,959,850 in 1913.

*Coal briquets.*—The production of coal briquets in the United States in 1916 was 295,155 short tons, valued at $1,445,662, against 221,537 tons, valued at $1,035,716, in 1915; 250,635 tons, valued at $1,154,678, in 1914; 181,859 tons, valued at $1,007,327, in 1913; and 220,064 tons, valued at $952,261, in 1912.

*Cobalt oxide.*—No cobalt oxide has been produced in this country from domestic ores since 1909. The imports of cobalt (oxide, ore, and zaffer) for consumption were valued at $367,245 in 1916, $219,111 in 1915, $274,538 in 1914, $95,735 in 1913, and $83,080 in 1912.

*Coke.*—The production of coke in 1916 amounted to 54,533,585 short tons, valued at the ovens at $170,841,197, against 41,581,150 tons, valued at $105,503,868, in 1915; 34,555,914 tons, valued at $88,334,217, in 1914; 46,299,530 tons, valued at $128,922,273, in 1913; and 43,983,599 tons, valued at $111,805,113, in 1912. The imports of coke for consumption were valued at $249,514 in 1916, $222,382 in 1915, $551,104 in 1914, $435,157 in 1913, and at $488,398 in 1912, and the exports at $4,202,236 in 1916, $3,092,498 in 1915, $2,233,686 in 1914, $3,309,930 in 1913, and $3,002,742 in 1912.

*Diatomaceous (infusorial) earth and tripoli.*—The value of the diatomaceous (infusorial) earth and tripoli produced in 1916 was $241,553 (exclusive of the value of a considerable production for special uses which the Survey is not at liberty to publish), against $167,474 in 1915, $252,327 in 1914, $285,821 in 1913, and $125,446 in 1912. The imports of diatomaceous earth, rottenstone, and tripoli for consumption were valued at $37,573 in 1916, $27,333 in 1915, $20,004 in 1914, $28,696 in 1913, and $24,253 in 1912.

*Emery and corundum.*—No corundum has been produced since 1906. The output of emery in 1916 was 15,282 short tons, valued at $123,901, against 3,063 tons, valued at $31,131, in 1915; 485 tons, valued at $2,425, in 1914; 957 tons, valued at $4,785, in 1913; and 992 tons, valued at $6,652, in 1912. The imports of emery and corundum for consumption were valued at $240,737 in 1916, $271,649 in 1915, $383,436 in 1914, $474,299 in 1913, and $491,725 in 1912.

*Feldspar.*—The production of feldspar in 1916 was 132,681 short tons, valued at $702,278, against 105,118 tons, valued at $489,223, in 1915; 135,419 tons, valued at $629,873, in 1914; 120,955 tons, valued at $776,551, in 1913; and 86,572 tons, valued at $520,562, in 1912.

*Fertilizers.*—Fertilizers, including apatite, bone dust, guano, kainite, kieserite, crude phosphates, and other manures, are shown under phosphate rock and under potash salts, and sodium nitrate is mentioned as such.

*Fluorspar and cryolite.*—The production of fluorspar in 1916 was 155,735 short tons, valued at the mines at $922,654, compared with 136,941 tons, valued at $764,475, in 1915; 95,116 tons, valued at $570,041, in 1914; 115,580 tons, valued at $736,286, in 1913; and 116,545 tons, valued at $769,163, in 1912. The imports of fluorspar in 1916 for consumption were 12,323 short tons, valued at $54,000,

compared with 7,167 tons, valued at $22,878, in 1915; 10,205 tons, valued at $38,943, in 1914; 22,682 tons, valued at $71,463, in 1913; and $26,176 tons, valued at $71,616, in 1912.

No cryolite is produced in the United States. The imports were valued at $165,222 in 1916, $82,750 in 1915, $94,424 in 1914, and $52,557 in 1913.

*Fuller's earth.*—The production of fuller's earth in 1916 was 67,822 short tons, valued at the mines at $706,951, against 47,901 tons, valued at $489,219, in 1915; 40,981 tons, valued at $403,646, in 1914; 38,594 tons, valued at $369,750, in 1913; and 32,715 tons, valued at $305,522, in 1912. The imports of fuller's earth (manufactured and unmanufactured) for consumption were valued at $139,664 in 1916, $152,493 in 1915, $195,083 in 1914, $146,001 in 1913, and $145,337 in 1912.

*Garnet.*—The production of abrasive garnet in 1916 amounted to 6,171 short tons, valued at $208,850, against 4,301 tons, valued at $139,584, in 1915; 4,231 tons, valued at $145,510, in 1914; 5,308 tons, valued at $183,422, in 1913; and 4,947 tons, valued at $163,237, in 1912. No record is kept of imports of abrasive garnet.

*Gems and precious stones.*—The value of gems and precious stones found in the United States in 1916 was $217,793, against $170,431 in 1915, $124,651 in 1914, $319,454 in 1913, and $319,722 in 1912. Imports of precious stones for consumption were valued at $38,930,127 in 1916, $21,719,693 in 1915, against $17,121,066 in 1914, $40,429,374 in 1913, and $36,232,949 in 1912.

*Graphite.*—The production of amorphous graphite in 1916 was 2,622 short tons, valued at $20,723, compared with 1,181 tons, valued at $12,358, in 1915; 1,725 tons, valued at $38,750, in 1914; 2,243 tons, valued at $39,428, in 1913; and 2,063 tons, valued at $32,894, in 1912. The production of crystalline graphite in 1916 amounted to 10,931,989 pounds, valued at $914,748, compared with 7,074,370 pounds, valued at $417,273, in 1915; 5,220,539 pounds, valued at $285,368, in 1914; 5,064,727 pounds, valued at $254,328, in 1913; and 3,543,771 pounds, valued at $187,689, in 1912. The production of manufactured graphite in 1916 was 8,397,281 pounds, compared with 5,084,000 pounds, valued at $99,633, in 1915; 10,455,139 pounds, valued at $698,800, in 1914; and 13,633,342 pounds, valued at $973,397, in 1913. The imports of graphite for consumption were valued at $7,279,884 in 1916, $2,241,163 in 1915, $1,398,209 in 1914, and at $2,109,791 in 1913.

*Grindstones and pulpstones.*—The value of all kinds of grindstones and pulpstones produced in 1916 was $766,140, against $648,479 in 1915, $689,344 in 1914, $855,627 in 1913, and $916,339 in 1912. The imports for consumption were valued at $63,277 in 1916, $68,892 in 1915, $109,539 in 1914, $139,386 in 1913, and $131,080 in 1912.

*Gypsum.*—The output of gypsum in 1916 was 2,757,730 short tons, valued at $7,959,032, compared with 2,447,611 tons, valued at $6,596,893, in 1915; 2,476,465 tons, valued at $6,895,989, in 1914; 2,599,508 tons, valued at $6,774,822, in 1913; and 2,500,757 tons, valued at $6,563,908, in 1912. The imports of gypsum for consumption were valued at $356,473 in 1916, $389,759 in 1915, $444,841 in 1914, $556,922 in 1913, and $488,481 in 1912.

*Lime.*—The production of lime in 1916 was 4,073,433 short tons, valued at $18,509,305, against 3,622,810 tons, valued at $14,424,036, in 1915; 3,380,928 tons, valued at $13,268,938, in 1914; 3,595,390 tons, valued at $14,648,362, in 1913; and 3,529,462 tons, valued at $13,970,114, in 1912. The imports of lime in 1916 for consumption were 7,959 short tons, valued at $71,663, against 1,956 tons, valued at $22,489, in 1915; 3,455 tons, valued at $33,670, in 1914; and 4,139 tons, valued at $48,538, in 1913. The exports were valued at $132,769 in 1916, $106,312 in 1915, $170,744 in 1914, and $212,345 in 1913.

*Lithium minerals.*—The production of lithium minerals in 1916 was 619 short tons, valued at $12,035, against 486 tons, valued at $9,867, in 1915; 525 tons, valued at $8,000, in 1914; 530 tons, valued at $14,900 in 1913; and 360 tons, valued at $6,800, in 1912.

*Magnesite.*—The production of crude magnesite in 1916 was 154,974 short tons, valued at $1,393,693, against 30,499 tons, valued at $274,491, in 1915; 11,293 tons, valued at $124,223, in 1914; 9,632 tons, valued at $77,056, in 1914; and 10,512 tons, valued at $84,096, in 1912. The imports of magnesia and magnesite for consumption were valued at $858,373 in 1916, $516,469 in 1915, $1,453,508 in 1914, $1,805,274 in 1913, and $1,430,542 in 1912.

*Marls.*—The quantity of calcareous marl burned or dried for agricultural use, some of which has been formerly included in the lime figures, is here stated for the first time. The total quantity of marl sold for this use in 1916 was 35,588 short tons, valued at $107,768. No considerable production of greensand marl has been reported since 1908. There was a very small output in 1916 as in preceding years.

*Mica.*—The production of mica in 1916 consisted of 4,433 short tons of scrap mica, valued at $69,906, and 865,863 pounds of sheet mica, valued at $524,485, against 3,959 tons of scrap, valued at $50,510, and 553,821 pounds of sheet, valued at $378,259, in 1915; 3,730 tons of scrap, valued at $51,416, and 556,933 pounds of sheet, valued at $278,540, in 1914; 5,322 tons of scrap, valued at $82,543, and 1,700,677 pounds of sheet, valued at $353,517, in 1913; and 3,226 tons of scrap, valued at $49,073, and 845,483 pounds of sheet, valued at $282,823, in 1912. The imports of mica for consumption were valued at $1,071,356 in 1916, $692,269 in 1915, $629,484 in 1914, $947,783 in 1913, and $755,584 in 1912.

*Millstones.*—The value of the production of millstones in 1916 was $44,559 against $53,480 in 1915, $43,316 in 1914, $56,163 in 1913, and $71,414 in 1912. The imports of burrstones and millstones for consumption were valued at $19,816 in 1916, $17,027 in 1915, $15,000 in 1914, $40,198 in 1913, and $27,562 in 1912.

*Mineral paints.*—The general canvass of the natural mineral pigment industry was discontinued after 1915, but the production of zinc and lead pigments in 1916 was 135,606 short tons, valued at $23,515,803, compared with 141,383 tons, valued at $14,962,461, in 1915; 106,791 tons, valued at $9,978,710, in 1914; 97,573 tons, valued at $9,020,896, in 1913; and 106,497 tons, valued ad $9,507,895, in 1912. Since 1912 the production of natural mineral pigments has been as follows: 57,442 short tons, valued at $551,598, in 1915; 66,766 tons, valued at $633,390, in 1914; 70,595 tons, valued at $512,410, in 1913; and 74,657 tons, valued at $561,693, in 1912.

Imports of ocher for consumption were valued at $181,153 in 1916, $137,823 in 1915, $141,704 in 1914, $143,720 in 1913, and $148,306 in 1912; of sienna, at $82,999 in 1916, $65,283 in 1915, $63,958 in 1914, $48,535 in 1913, and $45,794 in 1912; of umber, at $69,470 in 1916, $32,182 in 1915, $45,280 in 1914, $36,771 in 1913, and $31,626 in 1912; of zinc oxide, at $185,395 in 1916, $154,149 in 1915, $302,838 in 1914, $434,156 in 1913, and $386,153 in 1912.

*Mineral waters.*—The quantity of mineral waters marketed in 1916 was 55,928,461 gallons, valued at $5,735,035, compared with 52,113,503 gallons, valued at $5,138,794, in 1915; 54,358,466 gallons, valued at $4,892,328, in 1914; 57,867,399 gallons, valued at $5,631,391, in 1913; and 62,281,201 gallons, valued at $6,615,671, in 1912. The imports of mineral waters for consumption were valued at $624,302 in 1916, $551,648 in 1915, $857,707 in 1914, $955,788 in 1913, and $930,091 in 1912.

*Natural gas and gasoline.*—The value of natural gas produced in 1916 was $120,227,468, compared with $101,312,381 in 1915, $94,115,524 in 1914, $87,846,677 in 1913, and $84,563,957 in 1912. No imports of natural gas have been reported since 1909, when they were valued at $6,060, compared with $22,003 in 1908.

The production of gasoline extracted from casing-head gas (natural gas from oil wells) amounted in 1916 to 103,492,689 gallons, valued at $14,331,148, against 65,364,665 gallons, valued at $5,150,823, in 1915; 42,652,632 gallons, valued at $3,105,909, in 1914; 24,060,817 gallons, valued at $2,458,443, in 1913; and 12,081,179 gallons, valued at $1,157,476, in 1912. The imports of gasoline were valued at $185,286 in 1916, $38,756 in 1915, $587 in 1914, and $1,661 in 1913, and the exports in 1916, 1915, 1914, and 1913, at $33,614,957, $13,164,159, $19,897,613, and $17,418,777, respectively.

Exports of naphtha in 1916, 1915, 1914, and 1913 were $35,045,924, $20,720,888, $5,390,801, and $10,672,831, respectively.

*Oilstones, etc.*—The production of oilstones, etc., in 1916 was valued at $154,573, against $115,175 in 1915, $167,948 in 1914, $207,352 in 1913, and $232,218 in 1912. The imports for consumption were valued at $10,614 in 1916, $14,247 in 1915, $33,655 in 1914, $40,222 in 1913, and $45,398 in 1912.

*Peat.*—The production of peat in 1916 was valued at $369,104, against $288,537 in 1915, $309,692 in 1914, $197,200 in 1913, and $228,572 in 1912. The imports of peat for consumption were valued at $27,859 in 1916, $48,142 in 1915, $57,542 in 1914, and $55,719 in 1913.

*Petroleum.*—The quantity of crude petroleum marketed in 1916 was 300,767,158 barrels (42 gallons each), valued at $330,899,868, against 281,104,104 barrels, valued at $179,462,890, in 1915; 265,762,535 barrels, valued at $214,125,215, in 1914; 248,446,230 barrels, valued at $237,121,388, in 1913; and 222,935,044 barrels, valued at $164,213,247, in 1912. The imports of petroleum (including benzine) for consumption were valued at $12,788,270 in 1916, $10,444,210 in 1915, $11,464,879 in 1914, $12,945,619 in 1913, and $6,082,881 in 1912, and the exports of petroleum and its products (mineral oils except gasoline), were valued at $168,106,334 in 1916, against $129,777,510 in 1915, $120,002,974 in 1914, $131,897,632 in 1913, and $124,210,382 in 1912. The values given above for exports of petroleum and its products do not include fuel or bunker oil laden on

vessels engaged in the foreign trade, which aggregated $5,583,222 in 1916 and $3,161,341 in 1915. The imports of ozokerite and paraffin (oil and wax) for consumption were valued at $782,799 in 1916, $638,518 in 1915, $860,921 in 1914, $982,352 in 1913, and $1,018,524 in 1912. The exports of paraffin and paraffin wax were valued at $14,820,440 in 1916, $12,535,430 in 1915, $6,434,831 in 1914, $8,176,-831 in 1913, and $9,602,758 in 1912.

*Phosphate rock.*—The quantity of phosphate rock marketed in 1916 amounted to 1,982,385 long tons, valued at the mines at $5,986,993, compared with 1,835,667 tons, valued at $5,413,449, in 1915; 2,734,043 tons, valued at $9,608,041, in 1914; 3,111,221 tons, valued at $11,796,231, in 1913; and 2,973,332 tons, valued at $11,675,774, in 1912. The quantity of phosphate rock reported as mined during 1916 was 2,169,149 long tons, against 1,935,341 tons in 1915, 2,649,174 tons in 1914, and 3,152,208 tons mined in 1913. The imports of crude phosphates, guano, kainite, manure salts, etc., for consumption were valued at $4,104,647 in 1916, $3,970,039 in 1915, $9,921,439 in 1914, $10,819,253 in 1913, and $8,893,090 in 1912. The exports of phosphate rock were 243,678 long tons, valued at $1,156,391, in 1916, against 253,421 tons, valued at $1,603,851, in 1915; 964,114 tons, valued at $6,771,652, in 1914; 1,366,508 tons, valued at $9,996,580, in 1913; and 1,206,520 tons, valued at $8,996,456, in 1912.

*Potash.*—The year 1915 was epoch-making in the domestic potash industry. There were produced in this country that year soluble potash salts valued at $342,000. Quantities are not given for the reason that the product sold came from diverse sources and contained varying proportions of potash. Though this figure for value is of interest as a small beginning in the domestic potash-salts industry, it is practically of no importance in comparison with the total needs of the country, as the quantity it represents is consumed in less than a week in normal times. There was no actual production of potash salts in the United States in 1914. In 1916 the production of potash ($K_2O$) was, 9,720 short tons, valued at $4,242,730, or about ten times the output of 1915. The imports of potash salts (not including kainite and manure salts) for consumption were valued at $2,352,448 in 1916, $3,765,224 in 1915, $8,743,973 in 1914, and $10,805,720 in 1913.

*Pumice.*—The production of pumice amounted in 1916 to 33,320 short tons, valued at $82,263, against 27,708 tons, valued at $63,185, in 1915; 27,591 tons, valued at $59,172, in 1914; 24,563 tons, valued at $55,408, in 1913; and 27,146 tons, valued at $86,687, in 1912. The imports for consumption were valued at $116,543 in 1916, $65,691 in 1915, $92,668 in 1914, $93,408 in 1913, and $74,478 in1912.

*Pyrite.*—The production of pyrite in 1916 was 423,556 long tons, valued at $1,965,702, against 394,124 tons, valued at $1,674,933, in 1915; 336,662 tons, valued at $1,283,346, in 1914; 341,338 tons, valued at $1,286,084, in 1913; and 350,928 tons, valued at $1,334,259, in 1912. The imports of pyrite (containing more than 25 per cent of sulphur) for consumption were valued at $6,728,318 in 1916, $4,817,-977 in 1915, $4,797,326 in 1914, $3,611,137 in 1913, and $3,841,683 in 1912.

*Salt.*—The quantity of salt marketed in 1916 amounted to 6,362,906 short tons, valued at $13,645,947, compared with $5,352,409 tons, valued at $11,747,686, in 1915; 4,872,656 tons, valued at $10,197,417,

in 1914; 4,815,902 tons, valued at $10,123,139, in 1913; and 4,665,473 tons, valued at $9,402,772, in 1912. The imports for consumption were valued at $342,588 in 1916, against $366,452 in 1915, $380,803 in 1914, $421,745 in 1913, and $370,648 in 1912; and the exports at $567,441 in 1916, $613,847 in 1915, $586,055 in 1914, $515,194 in 1913, and $418,525 in 1912.

*Sand and gravel.*—The production of glass sand in 1916 was 2,018,317 short tons, valued at $1,957,797, compared with 1,884,044 tons, valued at $1,606,640, in 1915; 1,619,649 tons, valued at $1,568,030, in 1914; 1,791,800 tons, valued at $1,895,991, in 1913; and 1,465,386 tons, valued at $1,430,471, in 1912. The production of gravel and of sand for molding, building, engine, furnace, and other uses (exclusive of glass sand) was 87,073,415 short tons, valued at $27,852,198, against 74,719,259 tons, valued at $21,514,977, in 1915; 77,662,086 tons, valued at $22,278,969, in 1914; 77,764,049 tons, valued at $22,321,517, in 1913; and 66,889,175 tons, valued at $21,682,737, in 1912. The imports of sand for consumption were valued at $87,144 in 1916, $96,754 in 1915, $139,675 in 1914, $172,257 in 1913, and $141,690 in 1912.

*Sand-lime brick.*—The production of sand-lime brick was valued at $1,474,073 in 1916, $1,135,104 in 1915, $1,058,512 in 1914, $1,238,325 in 1913, and $1,200,223 in 1912.

*Silica (quartz).*—The production of silica (quartz) in 1916 was 88,514 short tons, valued at $242,786, against 112,575 tons, valued at $273,553, in 1915; 153,401 tons, valued at $360,502, in 1914; 97,902 tons, valued at $201,488, in 1913; and 97,874 tons, valued at $191,685, in 1912. The value of the flint and flint pebbles imported for consumption in 1916 was $313,120 in 1916, against $274,904 in 1915, $432,694 in 1914, $324,662 in 1913, and $289,904 in 1912.

*Slate.*—The production of slate in 1916 was valued at $5,338,837, against $4,958,915 in 1915, $5,706,787 in 1914, $6,175,476 in 1913, and $6,043,318 in 1912. The imports of slate (in the form of mantels, chimney pieces, roofing slate, slabs, etc.) were valued at $2,200 in 1916, at $2,768 in 1915, at $4,855 in 1914, and at $5,479 in 1913, and the exports of roofing slate in these years were valued at $27,630, $46,137, $139,125, and $226,413, respectively.

*Sodium nitrate.*—There is no domestic production of sodium nitrate. The imports of sodium nitrate for consumption amounted in value to $38,131,364 in 1916, $22,844,746 in 1915, $15,204,539 in 1914, $21,630,811 in 1913, and $16,544,511 in 1912.

*Stone.*—The value of all kinds of stone produced in the United States in 1916 amounted to $79,041,699, compared with $74,595,352 in 1915, $77,544,103 in 1914, $83,732,995 in 1913, and $78,193,220 in 1912. The imports of stone for consumption were valued in 1916 at $959,367, against $892,668 in 1915, $1,389,473 in 1914, $1,615,152 in 1913, and $1,562,231 in 1912. The exports were valued at $1,480,750 in 1916, against $1,036,124 in 1915, $1,363,242 in 1914, $1,856,892 in 1913, and $1,839,878 in 1912. Included under stone is the limestone used for fluxing in blast furnaces, which amounted in 1916 to 23,603,508 long tons, valued at $13,936,882, compared with 18,998,723 tons, valued at $9,672,347, in 1915; 15,298,756 tons, valued at $7,890,369, in 1914; 22,620,961 tons, valued at $11,103,989, in 1913; and 20,190,554 tons, valued at $9,937,772, in 1912.

*Strontium.*—The production of strontium in 1916 was 250 short tons, valued at $3,650. No strontium was reported as mined during 1915, 1914, or 1913. Imports of strontia oxide, protoxide of strontium, and strontianite were valued at $11,049 in 1916, $6,411 in 1915, $1,016 in 1914, and at $2,284 in 1913.

*Sulphur.*—The Survey is not at liberty to show the figures for production of sulphur in 1915 and 1916, these values being included in that for unspecified products. The marketed production of sulphur in 1914 was 327,634 long tons, valued at $5,954,236, against 311,590 tons, valued at $5,479,849, in 1913; and 303,472 tons, valued at $5,256,422, in 1912. The imports of sulphur for consumption were valued at $404,784 in 1916, against $472,458 in 1915, $477,937 in 1914, $448,564 in 1913, and $583,974 in 1912. The exports amounted to 128,755 long tons, valued at $2,505,857, in 1916, compared with 37,312 tons, valued at $724,679, in 1915; 98,163 tons, valued at $1,807,324, in 1914; 89,221 tons, valued at $1,599,761, in 1913; and 57,736 tons, valued at $1,076,414, in 1912.

*Sulphuric acid from copper and zinc smelters.*—The statistics of the recovery of sulphuric acid from the gases from copper and zinc smelters were collected by the Survey for the first time in 1911. This production (in terms of 60° Baumé) amounted in 1916 to 1,162,391 short tons (including 92,802 tons of stronger acid, reported as oleum, etc., and not reduced to 60° Baumé), valued at $14,099,927, compared with 904,653 tons (including 59,189 tons of stronger acid, reported as oleum, etc., and not reduced to 60° Baumé), valued at $7,621,241, in 1915; 760,638 tons, valued at $5,190,293, in 1914; 632,237 tons, valued at $4,346,272, in 1913; and 614,073 tons, valued at $4,240,941, in 1912.

*Talc and soapstone.*—Exclusive of the production of fibrous talc from Gouverneur, N. Y., the production of talc and soapstone in 1916 amounted to 119,725 short tons, valued at $1,292,293, compared with 98,677 tons, valued at $1,026,739, in 1915; 86,221 tons, valued at $1,043,801, in 1914; 94,128 tons, valued at $1,119,597, in 1913; and 93,413 tons, valued at $1,050,693, in 1912. The imports of talc for consumption were valued at $230,875 in 1916, $199,840 in 1915, $177,321 in 1914, $137,680 in 1913, and $122,956 in 1912. In 1916 the production of fibrous talc was 93,236 short tons, valued at $961,510, against 88,214 tons, valued at $864,843, in 1915; 86,075 tons, valued at $821,286, in 1914; 81,705 tons, valued at $788,500, in 1913; and 66,867 tons, valued at $656,270, in 1912.

*Thorium minerals (monazite) and zircon.*—The production of monazite sand in 1916 was 37,872 pounds, valued at $3,400, against 36,000 pounds, valued at $3,600, in 1915. Prior to 1915 there had been no production of monazite since 1910, and the gas-mantle industry of the United States has been supplied by imports of monazite from Brazil and of manuufactured thorium salts from Germany. The imports of thorium nitrate for consumption were 909 pounds, valued at $3,884, in 1916, against 67,247 pounds, valued at $170,268, in 1915, 101,927 pounds, valued at $239,376, in 1914; 119,044 pounds, valued at $230,628, in 1913; and 117,485 pounds, valued at $225,386, in 1912. The imports of monazite and thorium oxide were valued at $197,870 in 1916, compared with $161,805 in 1915, $63,282 in 1914, $68,542 in 1913, and $47,334 in 1912. There has been no

production of zircon since 1911, when 3,208 pounds, valued at $802, were reported.

## MINERAL PRODUCTION FROM 1880 TO 1916.

From the totals shown in the following table, "Mineral products of the United States in 1915 and 1916," duplication has been eliminated wherever practicable. For instance, the value of the coke has been excluded from the totals as the value of the coal used in its manufacture enters into the statistics of coal production. In mineral paints, the chemically manufactured pigments (white lead, red lead, lithopone, litharge, and orange mineral), whose aggregate value has exceeded $20,000,000 annually for the last 12 years, are not given in the table, as the base from which they are made is included in the output of lead or zinc, whereas the zinc and lead pigments (zinc white or zinc oxide, zinc-lead, leaded zinc oxide, sublimed blue lead, and sublimed white lead) are included, being made directly from the ores and not entering, therefore, into the lead or zinc totals. The value of the pig iron, rather than that of the iron ore, is included in the total, being considered the best means of presenting the statistics of iron in its first marketable condition. Similarly, the value of the products of the clay industries is included as representing the first marketable condition of the greater part of the clay produced. The quantity and value of the clay mined and sold in the raw state by miners to manufacturers of clay are shown separately, but the value is not included in the total.

*Mineral products of the United States in 1915 and 1916.*

| Product. | 1915 | | 1916 | | Increase or decrease in 1916. | | Percentage of increase or decrease in 1916. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| **Metallic.** | | | | | | | | |
| Aluminum.....pounds.. | ..... | $16,280,000 | ..... | $33,900,000 | ..... | + $17,620,000 | ..... | + 108 |
| Antimonial lead (a).....short tons (2,000 pounds).. | 23,224 | 3,665,736 | 24,038 | 4,483,582 | + 814 | + 817,846 | + 4 | + 22 |
| Antimony (b).....do.... | 5,364 | b 2,373,760 | (c) | (c) | (c) | (c) | (c) | (c) |
| Bauxite.....long tons (2,240 pounds).. | 297,041 | 1,514,834 | 425,100 | 2,296,400 | + 128,059 | + 781,566 | + 43 | + 52 |
| Cadmium.....pounds.. | 91,415 | 106,443 | 135,212 | 210,931 | + 43,797 | + 102,488 | + 48 | + 98 |
| Chromic iron ore.....long tons.. | 3,281 | 36,744 | 47,035 | 726,243 | + 43,754 | + 689,499 | +1,334 | +1,876 |
| Copper, d 1915, value at New York; 1916, sales value..lbs.. | 1,388,009,527 | 242,902,000 | 1,927,850,548 | 474,288,000 | +539,841,021 | + 231,386,000 | + 39 | + 95 |
| Ferroalloys..... | 388,644 | 17,450,385 | 589,738 | 50,281,692 | + 201,094 | + 32,831,307 | + 52 | + 188 |
| Gold (e).....troy ounces.. | 4,887,602 | 101,035,700 | 4,479,056 | 92,590,300 | − 408,546 | − 8,445,400 | − 8 | − 8 |
| Iron: | | | | | | | | |
| Ore (f).....long tons.. | 55,493,100 | f 101,288,984 | 77,870,553 | f 181,902,277 | + 22,377,453 | + 80,613,293 | + 40 | + 80 |
| Pig.....do.... | 30,384,486 | 401,409,604 | 39,126,324 | 663,478,118 | + 8,741,838 | + 262,068,514 | + 29 | + 65 |
| Lead (refined) (d), value at New York City.short tons.. | 507,026 | 47,660,000 | 552,228 | 76,207,000 | + 45,202 | + 28,547,000 | + 9 | + 60 |
| Manganese ore.....long tons.. | g 8,708 | g 108,049 | 26,997 | 627,417 | + 18,289 | + 519,368 | + 210 | + 481 |
| Manganiferous ore (h).....do.... | g 196,640 | g 822,216 | 548,803 | 2,005,491 | + 352,163 | + 1,183,275 | + 179 | + 144 |
| Nickel (i), value at New York City.....short tons.. | 822 | 538,222 | 918 | 671,192 | + 96 | + 132,970 | + 12 | + 25 |
| Platinum and allied metals, value at New York City.....troy ounces.. | 8,665 | 478,688 | 28,088 | 2,301,762 | + 19,423 | + 1,823,074 | + 224 | + 381 |
| Quicksilver, value at San Francisco, flasks (75 pounds net)..... | 21,033 | g 1,804,631 | 29,932 | 3,768,139 | + 8,899 | + 1,963,508 | + 42 | + 109 |
| Silver.....troy ounces.. | 74,961,075 | 37,397,300 | 74,414,802 | 48,953,000 | − 546,273 | + 11,555,700 | − 0.7 | + 31 |
| Tin (metallic equivalent).....pounds.. | 204,000 | 78,846 | 280,000 | 122,000 | + 76,000 | + 43,154 | + 37 | + 55 |
| Titanium ore (rutile).....short tons.. | 250 | 27,500 | 110 | 16,500 | − 140 | − 11,000 | − 56 | − 40 |
| Tungsten ore (60 per cent concentrates).....do.... | 2,332 | 4,100,000 | 5,923 | 12,074,000 | + 3,591 | + 7,974,000 | + 154 | + 194 |
| Uranium and vanadium minerals.....do.... | ..... | 693,750 | ..... | 500,000 | ..... | − 193,750 | ..... | − 28 |
| Zinc (d) (sales value).....do.... | 458,135 | 113,617,000 | 563,451 | 151,005,000 | + 105,316 | + 37,388,000 | + 23 | + 33 |
| **Total value of metallic products**..... | ..... | 991,729,648 | ..... | 1,620,506,767 | ..... | + 628,777,119 | ..... | + 63 |

a From both domestic and foreign ores.
b From all sources. Values excluded from metallic totals as the values of the antimony contained in antimonial lead are included in the antimonial-lead values, and the remainder under last item ("Unspecified").
c Figures not available. Estimate of value of the antimony other than that entering into antimonial lead included under last item ("Unspecified").
d Product from domestic ores only.
e Value, $20.67183625323 an ounce.
f Value not included in total value.
g Figures for 1915 revised in 1916.
h Exclusive of those ores from Lake Superior district running so low in manganese as to be classed with iron ore.
i By-product in electrolytic copper refining.

*Mineral products of the United States in 1915 and 1916*—Continued.

| Product. | 1915 | | 1916 | | Increase or decrease in 1916. | | Percentage of increase or decrease in 1916. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| **Nonmetallic.** | | | | | | | | |
| Arsenious oxide.....short tons.. | 5,498 | $302,116 | 5,986 | $555,187 | + 488 | + $253,071 | + 9 | + 84 |
| Asbestos.....do.... | 1,731 | 76,952 | 1,479 | 448,214 | − 252 | + 371,262 | − 15 | + 482 |
| Asphalt.....do.... | 740,254 | 5,242,073 | 786,811 | 7,102,132 | + 46,557 | + 1,860,059 | + 6 | + 35 |
| Barytes (crude).....do.... | 108,547 | 381,032 | 221,952 | 1,011,232 | + 113,405 | + 630,200 | + 104 | + 165 |
| Borax (crude).....do.... | 67,003 | 1,677,099 | 103,525 | 2,409,459 | + 36,522 | + 732,360 | + 55 | + 44 |
| Bromine.....pounds.. | 855,857 | 856,307 | 728,520 | 951,932 | − 127,337 | + 95,625 | − 15 | + 11 |
| Calcium chloride.....short tons.. | 20,535 | 130,830 | 26,062 | 216,729 | + 5,527 | + 85,899 | + 27 | + 66 |
| Cement.....barrels (376 pounds net).. | 87,685,222 | 75,155,102 | 95,394,433 | 104,689,090 | + 7,709,211 | + 29,533,988 | + 9 | + 39 |
| Clay: | | | | | | | | |
| Products..... | ..... | 163,120,232 | ..... | 207,260,091 | ..... | + 44,139,859 | ..... | + 27 |
| Raw (a).....short tons.. | 2,362,954 | a 3,971,941 | 2,932,590 | a 5,751,774 | + 569,636 | + 1,779,833 | + 24 | + 45 |
| Coal: | | | | | | | | |
| Bituminous (b).....do.... | 442,624,426 | 502,037,688 | 502,519,682 | 665,116,077 | + 59,895,256 | + 163,078,389 | + 14 | + 32 |
| Pennsylvania anthracite.....long tons.. | 79,459,876 | 184,653,498 | 78,195,083 | 202,009,561 | − 1,264,793 | + 17,356,063 | − 2 | + 9 |
| Coke (a).....short tons.. | 41,581,150 | a 105,503,868 | 54,533,585 | a 170,841,197 | + 12,952,435 | + 65,337,329 | + 31 | + 62 |
| Diatomaceous (infusorial) earth and tripoli.....do.... | ..... | c d 167,474 | ..... | d 241,553 | ..... | + 74,079 | ..... | + 44 |
| Emery.....do.... | 3,063 | 31,131 | 15,282 | 123,901 | + 12,219 | + 92,770 | + 399 | + 298 |
| Feldspar.....do.... | c 105,118 | c 489,223 | 132,681 | 702,278 | + 27,563 | + 213,055 | + 26 | + 44 |
| Fluorspar.....do.... | 136,941 | 764,475 | 155,735 | 922,654 | + 18,794 | + 158,179 | + 14 | + 21 |
| Fuller's earth.....do.... | 47,901 | 489,219 | 67,822 | 706,951 | + 19,921 | + 217,732 | + 42 | + 45 |
| Garnet for abrasive purposes.....do.... | 4,301 | 139,584 | 6,171 | 208,850 | + 1,870 | + 69,266 | + 43 | + 50 |
| Gems and precious stones..... | ..... | 170,431 | ..... | 217,793 | ..... | + 47,362 | ..... | + 28 |
| Graphite: | | | | | | | | |
| Amorphous.....short tons.. | 1,181 | 12,358 | 2,622 | 20,723 | + 1,441 | + 8,365 | + 122 | + 68 |
| Crystalline.....pounds.. | 7,074,370 | 417,273 | 10,931,989 | 914,748 | + 3,857,619 | + 497,475 | + 55 | + 119 |
| Grindstones and pulpstones..... | ..... | 648,479 | ..... | 766,140 | ..... | + 117,661 | ..... | + 18 |
| Gypsum.....short tons.. | 2,447,611 | 6,596,893 | 2,757,730 | 7,959,032 | + 310,119 | + 1,362,139 | + 13 | + 21 |
| Lime.....do.... | c 3,622,810 | c 14,424,036 | 4,073,433 | 18,509,305 | + 450,623 | + 4,085,269 | + 12 | + 28 |
| Magnesite (crude).....do.... | 30,499 | 274,491 | 154,974 | 1,393,693 | + 124,475 | + 1,119,202 | + 408 | + 408 |
| Mica: | | | | | | | | |
| Scrap.....do.... | 3,959 | 50,510 | 4,433 | 69,906 | + 474 | + 19,396 | + 12 | + 38 |
| Sheet.....pounds.. | 553,821 | 378,259 | 865,863 | 524,485 | + 312,042 | + 146,226 | + 56 | + 39 |
| Millstones..... | ..... | 53,480 | ..... | 44,559 | ..... | − 8,921 | ..... | − 17 |
| Mineral paints: | | | | | | | | |
| Natural pigments (e).....short tons.. | 57,442 | 551,598 | (f) | (f) | (f) | (f) | (f) | (f) |
| Zinc and lead pigments (e).....do.... | 141,383 | 14,962,461 | 135,606 | 23,515,803 | − 5,777 | + 8,553,342 | − 4 | + 57 |
| Mineral waters.....gallons sold.. | 52,113,503 | 5,138,794 | 55,928,461 | 5,735,035 | + 3,814,958 | + 596,241 | + 7 | + 12 |
| Natural gas..... | ..... | 101,312,381 | ..... | 120,227,468 | ..... | + 18,915,087 | ..... | + 19 |
| Natural-gas gasoline.....gallons.. | 65,364,665 | 5,150,823 | 103,492,689 | 14,331,148 | + 38,128,024 | + 9,180,325 | + 58 | + 178 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oilstones, etc. | | 115,175 | | 154,573 | | + 39,398 | | | + | 34 |
| Peat | | 288,537 | | 369,104 | | + 80,567 | | | + | 28 |
| Petroleum.....barrels (42 gallons) | 281,104,104 | 179,462,890 | 300,767,158 | 330,899,868 | + 19,663,054 | + 151,436,978 | + | 7 | + | 84 |
| Phosphate rock.....long tons | 1,835,667 | 5,413,449 | 1,962,385 | 5,896,993 | + 146,718 | + 483,544 | + | 8 | + | 9 |
| Potash ($K_2O$).....short tons | | 342,000 | 9,720 | 4,242,730 | | + 3,900,730 | | | +1,141 | |
| Pumice.....do | 27,708 | 63,185 | 33,320 | 82,263 | + 5,612 | + 19,078 | + | 20 | + | 30 |
| Pyrite.....long tons | 394,124 | 1,674,933 | 423,556 | 1,965,702 | + 29,432 | + 290,769 | + | 7 | + | 17 |
| Salt.....short tons | 5,352,409 | 11,747,686 | 6,362,906 | 13,645,947 | + 1,010,497 | + 1,898,261 | + | 19 | + | 16 |
| Sand: | | | | | | | | | | |
| Glass.....do | 1,884,044 | 1,606,640 | 2,018,317 | 1,957,797 | + 134,273 | + 351,157 | + | 7 | + | 22 |
| Molding, building, etc., and gravel.....do | 74,719,259 | 21,514,977 | 87,073,415 | 27,852,198 | + 12,354,156 | + 6,337,221 | + | 17 | + | 29 |
| Sand-lime brick | | 1,135,104 | | 1,474,073 | | + 338,969 | | | + | 30 |
| Silica (quartz).....short tons | 112,575 | 273,553 | 88,514 | 242,786 | − 24,061 | − 30,767 | − | 21 | − | 11 |
| Slate | | 4,958,915 | | 5,338,837 | | + 379,922 | | | + | 8 |
| Stone | | 74,595,352 | | 79,041,699 | | + 4,446,347 | | | + | 6 |
| Sulphur.....long tons | (g) | (g) | (g) | (g) | (g) | (g) | (g) | | (g) | |
| Sulphuric acid (60° Baumé) from copper and zinc smelters.....short tons | [h] 904,653 | 7,621,241 | [h] 1,162,391 | 14,099,927 | + 257,738 | + 6,478,686 | + | 28 | + | 85 |
| Talc and soapstone (exclusive of fibrous talc).....do | 98,677 | 1,026,739 | 119,725 | 1,292,293 | + 21,048 | + 265,554 | + | 21 | + | 26 |
| Talc, fibrous.....do | 88,214 | 864,843 | 93,236 | 961,510 | + 5,022 | + 96,667 | + | 6 | + | 11 |
| Thorium minerals (monazite).....pounds | 36,000 | 3,600 | 37,872 | 3,400 | + 1,872 | − 200 | + | 5 | − | 6 |
| **Total value of nonmetallic products** | | 1,398,565,121 | | 1,878,427,429 | | + 479,862,308 | | | + | 34 |
| **Total value of metallic products** | | 991,729,648 | | 1,620,506,767 | | + 628,777,119 | | | + | 63 |
| **Unspecified.** [i] | | | | | | | | | | |
| Metallic and nonmetallic (estimate) | | 7,450,000 | | [i] 15,000,000 | | + 7,550,000 | | | + | 101 |
| **Grand total** | [f] | 2,397,744,769 | | 3,513,934,196 | | +1,116,189,427 | | | + | 47 |

[a] Value not included in total value.
[b] Includes brown coal and lignite, and anthracite mined elsewhere than in Pennsylvania.
[c] Figures for 1915 revised in 1916.
[d] Exclusive of considerable production for special uses which is included under last item ("Unspecified").
[e] Natural pigments: Ocher, umber, sienna, metallic paint, mortar colors, and ground slate and shale. Zinc and lead pigments: Sublimed blue lead, sublimed white lead, leaded zinc oxide, zinc oxide, and zinc lead.
[f] Canvass discontinued in 1916. Value of iron ore sold for paint included under last item ("Unspecified").
[g] Value included under last item ("Unspecified").
[h] Includes 59,189 tons in 1915 and 92,802 tons in 1916 of stronger acid, reported as oleum, etc., not converted to 60° Baumé.
[i] Includes in 1916 antimony other than content of antimonial lead, bismuth, cadmium sulphide, chats, diatomaceous earth for special uses, ilmenite, iron ore sold for magnets and paint, lithium minerals, lithographic stone, magnesium, marls, molybdenum, pebbles for grinding, selenium, silica sand and sandstone (finely ground), strontium, sulphur, volcanic ash, and an estimate of the value of miscellaneous mineral products not collected annually by the Survey.

The following table and diagram show the value of the mineral production of the United States from 1880 to 1916, by years, separating the totals into values for metallic, nonmetallic, and unspecified products. The same principles have been followed in the eliminating of duplication from the totals for the earlier years as were followed for 1915 and 1916. For statistical data regarding any mineral prior to 1880, the first year for which general mineral statistics are available, the reader should consult the special chapter on the mineral concerned. Detailed figures by minerals for the years 1907 to 1916 will be found in the chart which is inclosed in the pocket.

*Total value of mineral products of the United States from 1880 to 1916.*

| Year. | Metallic. | Nonmetallic. | Unspecified (metallic and nonmetallic). | Total |
|---|---|---|---|---|
| 1880 | $187,880,880 | $173,581,917 | $6,000,000 | $367,462,797 |
| 1881 | 189,413,459 | 207,207,019 | 6,500,000 | 403,120,478 |
| 1882 | 215,820,070 | 230,785,547 | 6,500,000 | 453,105,617 |
| 1883 | 197,881,610 | 243,679,889 | 6,500,000 | 448,061,499 |
| 1884 | 180,284,208 | 221,755,346 | 5,000,000 | 407,039,554 |
| 1885 | 172,218,218 | 242,332,845 | 5,000,000 | 419,551,063 |
| 1886 | 204,399,872 | 250,985,090 | 800,000 | 456,184,962 |
| 1887 | 240,791,068 | 294,041,980 | 800,000 | 535,633,048 |
| 1888 | 242,010,000 | 310,888,983 | 900,000 | 553,798,983 |
| 1889 | 250,324,369 | 291,001,413 | 1,000,000 | 542,325,782 |
| 1890 | 303,440,430 | 310,968,907 | 1,000,000 | 615,429,337 |
| 1891 | 280,484,844 | 319,363,338 | 1,000,000 | 600,848,182 |
| 1892 | 283,715,295 | 337,516,444 | 1,000,000 | 622,231,739 |
| 1893 | 223,153,770 | 321,339,395 | 1,000,000 | 545,493,165 |
| 1894 | 186,835,353 | 362,409,394 | 1,000,000 | 550,244,747 |
| 1895 | 248,033,039 | 393,658,083 | 1,000,000 | 642,691,122 |
| 1896 | 252,075,130 | 387,965,870 | 1,000,000 | 641,041,000 |
| 1897 | 269,934,178 | 380,677,600 | 1,000,000 | 651,611,778 |
| 1898 | 308,247,446 | 417,794,018 | 1,000,000 | 727,041,464 |
| 1899 | 483,520,531 | 525,571,880 | 1,000,000 | 1,010,092,411 |
| 1900 | 513,731,959 | 594,194,796 | 1,000,000 | 1,108,926,755 |
| 1901 | 493,313,578 | 660,764,256 | 1,000,000 | 1,155,077,834 |
| 1902 | 604,517,044 | 722,433,728 | 1,000,000 | 1,327,950,772 |
| 1903 | 588,753,010 | 905,628,365 | 1,000,000 | 1,495,381,375 |
| 1904 | 501,114,224 | 859,074,529 | 400,000 | 1,360,588,753 |
| 1905 | 702,584,608 | 921,181,524 | 400,000 | 1,624,166,132 |
| 1906 | 886,179,981 | 1,016,390,015 | 200,000 | 1,902,769,996 |
| 1907 | 904,093,201 | 1,165,748,197 | 100,000 | 2,069,941,398 |
| 1908 | 550,744,388 | 1,043,702,454 | 250,000 | 1,594,696,842 |
| 1909 | 754,940,809 | 1,131,515,921 | 300,000 | 1,886,756,730 |
| 1910 | 749,876,234 | 1,241,039,986 | 300,000 | 1,991,216,220 |
| 1911 | 680,888,929 | 1,245,676,783 | 250,000 | 1,926,815,712 |
| 1912 | 866,381,073 | 1,378,310,236 | 500,000 | 2,245,191,309 |
| 1913 | 883,222,012 | 1,557,976,159 | 420,000 | 2,441,618,171 |
| 1914 | 691,081,734 | 1,426,754,508 | 470,000 | 2,118,306,242 |
| 1915 | 991,729,648 | 1,398,565,121 | 7,460,000 | 2,397,744,769 |
| 1916 | 1,620,506,767 | 1,878,427,429 | 15,000,000 | 3,513,934,196 |
| Grand total | 17,904,122,969 | 25,370,928,965 | 79,040,000 | 43,354,091,934 |

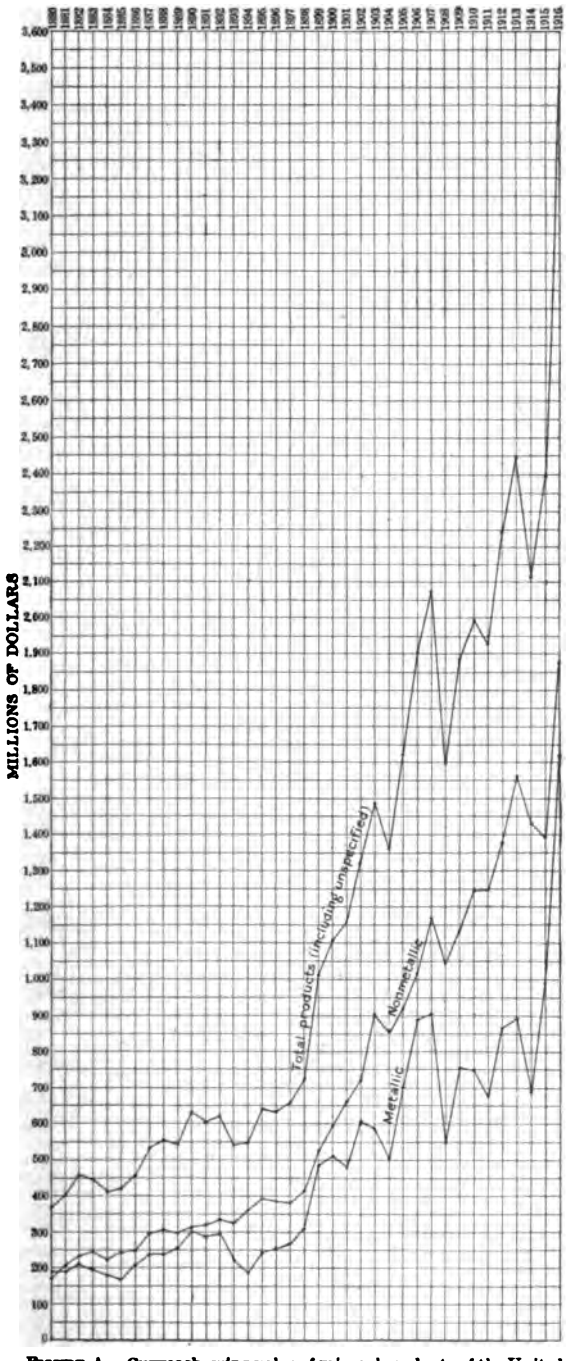


FIGURE A.—Curves showing value of mineral products of the United States, 1880–1916.

## IMPORTS AND EXPORTS.[1]

*Value of imports of products of the mine and manufactures of mine products for the calendar years 1915 and 1916.*

| Product. | 1915 | 1916 |
|---|---|---|
| Acid: | | |
| Chromic | $755 | ..... |
| Salicylic | 18,373 | $398 |
| Sulphuric or oil of vitriol | 69,920 | 21,672 |
| Agricultural implements, and parts of | 448,060 | 379,851 |
| Aluminum and manufactures of | 1,841,779 | 1,785,870 |
| Aluminum salts | 34,320 | 68,660 |
| Alizarin: | | |
| Natural or synthetic and dyes derived from | 854,818 | 67,036 |
| Natural | ..... | 18,279 |
| Synthetic | ..... | 25,893 |
| Colors, cakes, or dyes derived or manufactured from | ..... | 11,021 |
| Ammonia sulphate | 1,934,625 | 954,815 |
| Aniline salts | 64,806 | 4 |
| Antimony (crude and ore) | 332,125 | 1,072,340 |
| Antimony (metal or regulus) | 2,660,830 | 3,548,507 |
| Antimony (oxide and salts of) | 132,193 | 109,832 |
| Arsenic, sulphides, etc | 267,776 | 232,694 |
| Asbestos (unmanufactured) | 1,981,483 | 3,303,470 |
| Asbestos (manufactured—woven fabric and yarn) | 21,686 | 24,282 |
| Asbestos, all other | 117,833 | 113,636 |
| Asphaltum limestone rock | 19,001 | 1,795 |
| Asphaltum, manufactures | 681 | 17,768 |
| Asphaltum, all other | 661,356 | 732,917 |
| Barium products: | | |
| Manufactured barytes | 10,736 | 2,072 |
| Lithopone | 144,567 | 414,592 |
| Barium carbonate— | | |
| Natural | 12,165 | 18,169 |
| Manufactured | 2,786 | ..... |
| Barium binoxide | 218,776 | 6,590 |
| Barium chloride | 31,295 | 608 |
| Blanc-fixe | 18,501 | 17,810 |
| Barytes, crude | 4,877 | 245 |
| Bauxite, crude | 17,107 | 87 |
| Bells, broken, and bell metal fit only to be remanufactured | 246 | 6,368 |
| Bismuth | 108,288 | 195,975 |
| Borax (including crude borax, borate of soda, and boracic acid) | 21,281 | 20,043 |
| Brass, old, fit only for remanufacture | 1,809,827 | 6,578,653 |
| Burrstones and millstones | 17,027 | 19,816 |
| Cadmium | 284 | ..... |
| Cement, hydraulic | 57,174 | 4,942 |
| Cerium, cerite or cerium ore | 4,080 | 7 |
| Chalk, crude | 79,950 | 112,671 |
| Ground or bolted | 486 | ..... |
| Precipitated | 42,420 | 27,713 |
| Cubes, blocks, sticks, tailors, billiards, red | 4,592 | 4,096 |
| French, cut, powdered, washed or pulverized | 129 | 628 |
| Manufactures of, not elsewhere specified | 160 | 249 |
| Chromic iron ore | 780,061 | 1,548,402 |
| Chromium salts | 3,657 | 75 |
| Clay: | | |
| Kaolin or china clay | 1,152,778 | 1,326,684 |
| Other than kaolin | 165,369 | 177,549 |
| Clay products: | | |
| Brick and tile | 159,415 | 164,247 |
| Flattening stones | 12,386 | 833 |
| Pipes, common tobacco pipes and pipe bowls of clay | 15,155 | 10,378 |
| Pottery, etc | 6,612,931 | 5,590,207 |
| Coal: | | |
| Anthracite | 4,224 | 7,202 |
| Bituminous | 4,410,772 | 4,736,631 |
| Cobalt and cobalt ore and zaffer | 70,283 | 175,236 |
| Oxide | 148,828 | 192,009 |
| Coke | 222,382 | 249,514 |
| Copper in ore, matte, ingots, bars and manufactures | 44,394,592 | 94,469,458 |
| Corundum and emery | 271,649 | 240,737 |
| Cryolite | 82,750 | 165,222 |
| Diatomaceous earth, rotten stone and tripoli | 27,333 | 37,573 |
| Explosives: | | |
| Fulminates, fulminating powders, etc | 59,277 | ..... |
| All other | 193,408 | 229,194 |
| Gunpowder and all other substances, not specially provided for | 149,488 | 7,259,814 |
| Mining, blasting or safety fuses of all kinds | 35,249 | 3,378 |
| Percussion caps | 1,719 | 3,123 |
| Blasting caps | ..... | 2,453 |

[1] Compiled by James A. Dorsey from records of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce.

*Value of imports of products of the mine and manufactures of mine products for the calendar years 1915 and 1916*—Continued.

| Product. | 1915 | 1916 |
|---|---|---|
| Explosives—Continued. | | |
| Bombs, rockets, Roman candles and fireworks | $4,059 | $1,507 |
| Firecrackers | 159,408 | 291,830 |
| Fertilizers: | | |
| Crude (guano, kainite, manure salts, phosphate, etc.) | 3,970,039 | 4,104,647 |
| Potassium chloride | 2,296,606 | 348,961 |
| Potassium sulphate | 664,484 | 81,684 |
| Other potassium salts | 804,134 | 1,921,803 |
| Sodium nitrate | 22,844,746 | 38,131,364 |
| Ferroalloys: | | |
| Ferrochrome and (chromium) | 1,662 | 1,998 |
| Ferromanganese (and manganese) | 3,333,699 | 9,240,528 |
| Ferromolybdenum (and molybdenum) | 203 | ..... |
| Ferrophosphorus | 617 | ..... |
| Ferrosilicon | 311,219 | 384,384 |
| Ferrotitanium (and titanium) | ..... | 8,126 |
| Ferrotungsten (and tungsten) | 9,588 | 157,711 |
| Ferrovanadium | ..... | ..... |
| Spiegeleisen | 5,110 | ..... |
| Flint, flints, and flint stones | 274,904 | 313,120 |
| Fluorspar | 22,878 | 54,000 |
| Fullers earth | 152,493 | 139,664 |
| Gems and precious stones (including diamond dust and bort) | 21,719,693 | 38,930,127 |
| Granite | 144,382 | 75,697 |
| Graphite | 2,241,163 | 7,279,884 |
| Grindstones, finished and unfinished | 68,892 | 63,277 |
| Gypsum | 389,759 | 356,473 |
| Hones, oilstones, and whetstones | 14,247 | 10,614 |
| Ichthyol | 28,560 | 93,762 |
| Iron ore | 4,181,645 | 4,566,514 |
| Lead in ore, base bullion, pigs, sheets, etc | 772,955 | 1,014,959 |
| Lead paints, litharge, orange mineral, red lead, white lead | 40,223 | 21,783 |
| Lime | 22,489 | 71,663 |
| Lithographic stones, not engraved | 8,870 | 983 |
| Magnesia | 29,258 | 19,743 |
| Magnesite | 487,211 | 838,630 |
| Manganese oxide and ore of | 2,655,980 | 8,640,065 |
| Marble and stone (exclusive of granite) | 748,286 | 883,670 |
| Mica (unmanufactured, ground and cut) | 692,269 | 1,071,356 |
| Mineral water | 551,648 | 624,302 |
| Monazite sand and thorium oxide | 161,805 | 197,870 |
| Nickel, in ore, matte, oxide, and manufactures of | 7,636,144 | 9,925,220 |
| Ocher | 137,823 | 181,153 |
| Peat | 48,142 | 27,859 |
| Petroleum and products of: | | |
| Crude | 10,389,012 | 12,602,811 |
| Benzine, gasoline, and naphtha | 38,756 | 185,286 |
| Ozokerite | 210,019 | 196,185 |
| Paraffin oil | 85,121 | 75,925 |
| Paraffin wax | 343,378 | 510,689 |
| All other | 51,192 | 1,023,241 |
| Carbons made entirely from petroleum coke | 4,811 | 3,925 |
| Platinum and allied metals: | | |
| Crude platinum and unmanufactured products, ingots, bars, sheets, wires and scrap | 2,341,476 | 3,138,087 |
| Manufactured products, vases, retorts, etc | 71,532 | 18,591 |
| All other, not specially provided for | 2,267 | 3,281 |
| Iridium, osmium, palladium, rhodium, ruthenium | 347,676 | 533,615 |
| Osmiridium | 5,737 | 17,241 |
| Pumice | 65,691 | 116,543 |
| Pyrite | 4,817,977 | 6,728,318 |
| Quicksilver | 282,752 | 515,919 |
| Salt | 366,452 | 342,588 |
| Sand | 96,754 | 87,144 |
| Sienna | 65,283 | 82,999 |
| Slate | 2,768 | 2,200 |
| Strontium salts | 6,411 | 11,049 |
| Sulphur | 472,458 | 404,784 |
| Talc | 199,840 | 230,875 |
| Thorium nitrate | 170,268 | 3,884 |
| Tin, in bars, blocks, pigs, or grain, or granulated | 38,736,909 | 51,802,232 |
| Scrap | 117,688 | 144,281 |
| Tungsten-bearing ore | 1,044,986 | 7,353,691 |
| Type metal | 107,607 | 83,816 |
| Umber | 32,182 | 69,470 |
| Uranium salts and oxide, including some radium salts | 17,288 | 5,065 |
| Venetian red | 16,507 | 10,811 |
| Zinc in ore, pigs, sheets, dust, manufactures | 1,585,494 | 4,184,745 |
| Zinc oxide | 154,149 | 185,395 |
| Total | 212,930,613 | 357,263,610 |
| Increase | ..... | 144,332,997 |
| Percentage of increase | ..... | 67.78 |

*Value of imports of iron and steel and their manufactured products for the calendar years 1915 and 1916.*

| Product. | 1915 | 1916 |
|---|---|---|
| Scrap iron and steel, fit only for remanufacture | $761,737 | $1,113,186 |
| Slabs, blooms, loops, or other forms, etc | 95,054 | 15,161 |
| Rolled or hammered: | | |
| Bar iron | 208,437 | 290,998 |
| Bars of iron or steel, cold-rolled, hammered, or polished, etc | 2,891 | 20,990 |
| Bars or shapes of rolled or hammered iron, and round iron in coils, not otherwise provided for | 143,958 | 173,431 |
| Muck rakes | 64,658 | 196,838 |
| Square iron | 8 | 77 |
| Crucible steel | 123 | 4,830 |
| Steel ingots, cogged ingots, etc., if made by Bessemer, Siemens-Martin, or similar process not containing alloys | 163,386 | 430,323 |
| Steel bars and tapered or beveled bars, mill shafting, pressed, sheared, etc., not advanced in value or condition by any process or operation subsequent to the process of stamping; all descriptions and shapes of dry sand, loam, or iron-molded steel castings if made by the Bessemer, Siemens-Martin, open hearth, or similar process not containing alloys | 448,536 | 1,174,869 |
| Steel ingots, cogged, blooms, and slabs, die blocks or blanks: fillets and bars, pressed, sheared, or stamped shapes, not advanced in value or condition, subsequent to the process of stamping, gun-barrel molds not in bars, alloys used as substitutes for steel in the manufacture of tools, all descriptions and shapes of dry sand, loam, or iron-molded steel castings and steel not specially provided for, if made by the crucible, electric, or cementation process, either with or without alloys, and finished by rolling, hammering, or otherwise | 1,335,580 | 1,592,156 |
| Steel, by whatever process made, not specially provided for, containing alloys, such as nickel, cobalt, vanadium, chromium, tungsten, or wolfram, molybdenum, titanium, iridium, uranium, tantalum, boron, and similar alloys | 15,654 | 65,732 |
| Strips of iron and steel, not specially provided for | 3,174 | 13,335 |
| Galvanized or coated with zinc or spelter, or any alloy of these metals | 5,341 | 460 |
| Hoop, band, or scroll iron or steel, not specially provided for | 1,390 | 24 |
| Galvanized or coated with zinc or spelter, or any of these alloys | 9,126 | 8 |
| Boiler or other plate iron or steel (except crucible plate steel and saw plates) | 2,934 | 1,170 |
| Galvanized or coated with zinc or spelter, or other metals or any alloy of these metals | 388 | ..... |
| Sheets of iron or steel, common or black, and skelp iron or steel, etc | 4,145 | 2,833 |
| Cold rolled, smoothed only, not polished | 801 | ..... |
| Galvanized or coated with zinc or spelter, or other metals, or any alloy of these metals (excepting what are commercially known as tinplates, terneplates, and taggers tin) | 1,650 | 896 |
| Corrugated or crimped | 252 | 1,676 |
| Sheets of iron or steel, polished, planished, or glanced | 14,118 | 5,361 |
| Sheets and plates, when made by the Bessemer, Siemens-Martin, open hearth, or similar process, not containing alloys | 88,046 | 188,678 |
| Cold-rolled, smoothed only, not polished | 4,057 | 56 |
| Cold-hammered, blued, brightened, tempered, or polished by any process or polish better than the grade of cold-rolled, smoothed only | 27 | 1,275 |
| Galvanized, or coated with zinc, spelter, or any alloy of these metals | 3,117 | 539 |
| Sheets and plates (except saw plates) when made by the crucible, electric, or cementation process, with or without alloys, and finished by rolling, hammering, or otherwise | 56,878 | 112,669 |
| Cold rolled, smoothed only, not polished | 4,473 | 4,167 |
| Cold hammered, blued, brightened, tempered, or polished by any process to such perfected surface finish or polish better than grade of cold rolled, smoothed only | 136 | 4,561 |
| Galvanized or coated with zinc, spelter, or any alloy of these metals | 2,069 | 1,476 |
| Saw plates, cut or sheared to shape or otherwise unsheared | 36,838 | 21,426 |
| Tin plates, sheets, or plates cut of iron or steel, or taggers iron or steel coated with tin or lead, by dipping or any other process, and commercially known as tin plates, terneplates, and taggers tin | 196,218 | 204,472 |
| Coated with metal | 368 | 13 |
| Wire rods, total | 392,632 | 513,196 |
| Wire and manufactures of wire | 640,925 | 543,395 |
| Anvils | 19,926 | 17,489 |
| Bars or rails for railways: | | |
| Steel, or in part steel | 2,088,519 | 739,881 |
| Beams, girders, angles, channels, car-truck channels, sashes and frames, building frames, and all other structural shapes of iron or steel | 151,367 | 150,811 |
| Bolts, with or without threads or nuts, blanks, and finished hinges or hinge blanks of iron or steel | 14,646 | 22,794 |
| Tempered round steel wire | 248,976 | 131,365 |
| Castings: | | |
| Cast-iron pipe of every description | 4,222 | 4,131 |
| Cast-iron plates, stove plates, and iron plates, sadirons, tailor's irons, and vessels wholly of cast iron | 7,976 | 45,908 |
| Cast-iron plates, chiseled, machined, or otherwise advanced, but not made up into articles or finished parts | 4,032 | 4,132 |
| Malleable iron castings, not specially provided for | 29,170 | 111,029 |
| Sprocket or machine chains made of iron or steel | 108,064 | 49,815 |

*Value of imports of iron and steel and their manufactured products for the calendar years 1915 and 1916*—Continued.

| Product. | 1915 | 1916 |
|---|---|---|
| Cutlery: | | |
| Pen or pocket knives, etc | $555,013 | $149,215 |
| Razors and parts of | 189,162 | 38,462 |
| Scissors and shears, and blades for finished or unfinished | 323,650 | 139,442 |
| Knives, carving, etc., butcher, etc | 148,321 | 135,717 |
| Files, file blanks, rasps, and floats of all cuts and kinds | 28,128 | 56,925 |
| Forgings: | | |
| Ball bearing | 1,620,163 | 1,451,919 |
| Of iron or steel but not machined or advanced, not specially provided for | 33,536 | 41,811 |
| Machines, machinery, and parts of, not elsewhere specified: | | |
| Cream separators, value not to exceed $75, and parts of | 374,755 | 618,930 |
| Machine tools | 106,849 | 163,394 |
| Sewing machines | 223,057 | 77,604 |
| Embroidering and lace-making machines, lace curtains, nets or netting | 368,335 | 287,328 |
| All other textile machinery | 225,712 | 812,234 |
| Typewriters | 5,471 | 6,072 |
| All other machines and parts of machines, not elsewhere specified | 2,059,396 | 1,835,398 |
| Nails, spikes, and tacks | 44,137 | 51,371 |
| Needles: | | |
| Crochet and tape needles, knitting, and all other, not specially provided for | 112,088 | 129,355 |
| Hand sewing and darning | 387,364 | 499,445 |
| Knitting or sewing machine needles | 120,708 | 19,134 |
| Nippers and pliers of all kinds (except blacksmith tongs) wholly or partly manufactured | 55,450 | 22,047 |
| Railway fishplates or splice bars, of iron or steel | 15,116 | 11,978 |
| Saws, total | 31,163 | 24,801 |
| Table, kitchen, and hospital utensils or other hollow ware of iron or steel enameled or glazed with vitreous glasses | 364,909 | 294,606 |
| Tanks or vessels, cylindrical or tubular, for holding gas, liquid, or other material | 231,507 | 256,012 |
| Tubes, finished, not specially provided for | 40,911 | 10,185 |
| All other manufactures of iron and steel, not specially provided for | 891,252 | 2,356,462 |
| All other classes of manufactures of iron and steel not herein specified | 4,630,002 | 10,612,462 |
| Total imports of iron and steel, and their manufactured products | 20,572,198 | 28,079,941 |
| Increase | | 7,507,743 |
| Percentage of increase | | 36.49 |

*Value of exports of products of the mine and manufactures of mine products for the calendar years 1915 and 1916.*

| | 1915 | 1916 |
|---|---|---|
| **Mine products.** | | |
| Asbestos ore and manufactured | | $6,133 |
| Asphaltum | $735,952 | 759,769 |
| Bauxite concentrates | 717,186 | 987,454 |
| Clay: | | |
| Fire | | 144,552 |
| All other | | 154,163 |
| Coal: | | |
| Anthracite | 18,429,255 | 22,470,147 |
| Bituminous | [a] 42,817,341 | [a] 45,828,092 |
| Copper ore, matte, and regulus | 107,207 | |
| Ore | 290,913 | 1,006,826 |
| Concentrates | 55,005 | 232,241 |
| Graphite or plumbago | 52,583 | 98,118 |
| Iron ore | 2,181,629 | 3,702,496 |
| Mica | 5,118 | 4,544 |
| Petroleum, crude | 4,282,827 | 7,029,923 |
| Phosphate rock, ground or unground, not acidulated | 331,524 | 286,948 |
| Land pebble | 1,269,659 | 863,078 |
| All other | 2,668 | 6,365 |
| Platinum, unmanufactured | | 97,988 |
| Quicksilver | 225,509 | 670,475 |
| Salt | 613,847 | 567,441 |
| Sand and gravel | | 233,310 |
| Stone, including marble, unmanufactured | 400,510 | 403,303 |
| Sulphur or brimstone | 724,679 | 2,505,857 |
| Zinc ore | 35,276 | 3,992 |
| Total mine products | 73,278,688 | 88,063,215 |
| Increase | | 14,784,527 |
| Percentage of increase | | 20.18 |

[a] Does not include fuel or bunker coal laden on vessels engaged in the foreign trade, which aggregated in value $25,192,966 in 1915 and $27,491,822 in 1916.

*Value of exports of products of the mine and manufactures of mine products for the calendar years 1915 and 1916*—Continued.

| | 1915 | 1916 |
|---|---|---|
| **Manufactured products.** | | |
| Abrasives: | | |
| Wheels, emery and other | $1,200,421 | $2,240,227 |
| All other (exclusive of burrstones, grindstones, and whetstones) | 1,403,796 | 2,035,951 |
| Acid, sulphuric | 998,249 | 1,847,995 |
| Aluminum and manufactures | 8,682,117 | 15,417,134 |
| Asbestos manufactures | 764,050 | 1,209,076 |
| Asphaltum | 438,685 | 494,895 |
| Brass: | | |
| Scrap and old | 1,259,637 | 1,305,075 |
| Bars, plates, sheets, etc | 12,435,782 | 72,683,685 |
| Articles made from | 41,146,025 | 241,667,971 |
| Cement, hydraulic | 3,361,451 | 3,828,231 |
| Clay products: | | |
| Brick and tile | 1,531,210 | 2,999,036 |
| Pottery, etc | 1,174,030 | 1,856,494 |
| Coke | 3,092,498 | 4,202,236 |
| Copper: | | |
| Pigs, ingots, bars, rods, plates, sheets, etc | 114,411,914 | 198,537,500 |
| Wire (except insulated) | 2,838,902 | 6,386,674 |
| All other manufactures of | 7,885,472 | 25,752,591 |
| Sulphate of copper (or blue vitriol) | 680,966 | 2,803,833 |
| Ferrotungsten and tungsten metal | | 1,352,631 |
| Ferrovanadium | 741,085 | 2,035,276 |
| Graphite or plumbago | 536,572 | 1,339,259 |
| Agricultural implements, and parts of: | | |
| Hayrakes and tedders | 212,934 | 299,107 |
| Mowers and reapers (exclusive of lawn mowers) | 4,367,181 | 7,262,240 |
| Planters and seeders | 274,391 | 340,477 |
| Plows and cultivators | 3,371,915 | 5,199,162 |
| Thrashers | 1,563,245 | 1,933,974 |
| All other (including corn huskers, shellers and shredders, fanners, and cane mills, etc.) | 3,793,183 | 7,104,765 |
| Iron and steel: | | |
| Pig iron | 8,667,167 | 15,381,431 |
| Scrap and old, fit only for remanufacture | 1,111,254 | 3,689,675 |
| Adding and calculating machines | 554,984 | 1,428,131 |
| Air-compressing machines | 503,633 | 883,327 |
| Apparatus, scientific, etc., medical, surgical, and optical | 2,351,876 | 3,705,490 |
| All other | 1,299,918 | 3,638,344 |
| Arc lamps | 23,963 | 15,467 |
| Automobiles and parts of: | | |
| Commercial | 59,839,303 | 52,870,774 |
| Passenger | 35,045,090 | 43,725,087 |
| Barbed wire | 13,933,234 | 31,230,905 |
| All other wire | 11,900,373 | 20,994,035 |
| Bar iron | 1,471,466 | 3,913,847 |
| Bars or rods of steel: | | |
| Wire rods | 4,713,109 | 8,109,111 |
| All other | 16,412,440 | 47,670,406 |
| Bathtubs | 122,969 | 172,894 |
| Bicycles, tricycles, etc., motorcycles | 3,431,782 | 4,312,948 |
| Billets, ingots, and blooms | 14,176,528 | 99,165,269 |
| Bolts, nuts, rivets, and washers | 1,896,842 | 3,134,748 |
| Brewers' machinery | 60,427 | 14,915 |
| Builders' hardware (locks, hinges, and others) | 5,897,550 | 6,858,574 |
| Car wheels | 572,393 | 1,424,339 |
| Cash registers, and parts of | 1,376,201 | 1,767,382 |
| Castings, not elsewhere specified | 1,693,020 | 5,287,430 |
| Cutlery— | | |
| Razors | 1,205,332 | 2,181,998 |
| Table | 162,037 | 426,501 |
| Other | 1,428,567 | 2,013,019 |
| Dynamos or generators | 1,872,191 | 1,876,565 |
| Electric locomotives | 228,479 | 615,821 |
| Elevators and elevator machinery | 1,079,098 | 1,801,319 |
| Engines, and parts of: | | |
| Internal combustion: | | |
| Gas, stationary | 457,409 | 406,297 |
| Gasoline: | | |
| Automobile | 2,333,071 | 2,480,650 |
| Marine | 1,246,221 | 3,370,703 |
| Stationary | 1,549,242 | 2,977,336 |
| Traction | 1,303,209 | 5,494,347 |
| Steam: | | |
| Marine | 53,873 | 52,220 |
| Stationary | 361,754 | 521,301 |
| Traction | 265,155 | 1,169,476 |
| All other engines, and parts of | 5,843,856 | 18,517,592 |
| Firearms | 12,166,481 | 42,125,169 |
| Hoop, band, and scroll | 1,433,879 | 3,251,852 |
| Horseshoes | 2,741,724 | 1,007,198 |

*Value of exports of products of the mine and manufactures of mine products for the calendar years 1915 and 1916*—Continued.

| | 1915 | 1916 |
|---|---|---|
| **Manufactured products**—Continued. | | |
| Iron and steel—Continued. | | |
| Laundry machinery, and all other | $566,624 | $283,945 |
| Lawn mowers | 282,175 | 215,837 |
| Locomotives (steam) | 9,779,715 | 9,669,446 |
| Metal-working machinery (including metal-working tools) | 42,037,779 | 79,698,861 |
| Meters, gas and water | 246,617 | 364,050 |
| Milling machinery, flour and grist | 2,414,674 | 2,043,765 |
| Mining machinery: | | |
| Oil-well machinery | 1,220,009 | 1,980,319 |
| All other | 5,728,270 | 7,248,172 |
| Motors | 3,278,413 | 4,930,396 |
| Nails and spikes: | | |
| Cut | 190,667 | 312,195 |
| Railroad spikes | 591,752 | 1,489,091 |
| Wire | 4,371,072 | 10,794,418 |
| All other (including tacks) | 1,085,416 | 1,637,051 |
| Paper and pulp machinery | 908,947 | 1,285,500 |
| Pipes and fittings: | | |
| Cast | 2,128,025 | 3,988,293 |
| Wrought | 8,081,416 | 13,195,096 |
| Printing presses | 1,435,037 | 1,987,092 |
| Pumps and pumping machinery | 3,463,480 | 5,634,297 |
| Radiators and cast-iron house-heating boilers | 183,523 | 232,845 |
| Rails for railways of steel | 12,095,170 | 20,393,449 |
| Railway track material, switches, frogs, fishplates, etc. (except rails and spikes) | 4,857,047 | 6,532,627 |
| Refrigerating machinery (including ice-making machinery) | 802,542 | 677,196 |
| Safes | 214,638 | 392,130 |
| Scales and balances | 851,089 | 1,367,170 |
| Sheets and plates: | | |
| Galvanized | 5,381,303 | 8,350,005 |
| Iron sheets and plates | 1,221,699 | 3,129,041 |
| Steel: | | |
| Plates | 8,037,551 | 16,499,757 |
| Sheets | 3,726,933 | 6,546,814 |
| Shoe machinery | 1,451,462 | 1,107,851 |
| Stoves and ranges, and parts of | 1,602,008 | 1,620,238 |
| Structural iron and steel | 8,960,411 | 17,710,698 |
| Sugar-mill machinery | 5,362,971 | 9,058,347 |
| Textile machinery | 1,882,920 | 3,542,036 |
| Tin plates, terneplates, and taggers tin | 11,501,995 | 21,352,177 |
| Tools, not elsewhere specified: | | |
| Axes | 588,443 | 722,520 |
| Hammers and hatchets | 509,824 | 366,161 |
| Saws | 1,294,447 | 2,923,055 |
| Shovels and spades | 352,727 | 666,407 |
| All other | 8,676,483 | 12,716,778 |
| Transformers | 737,680 | 1,051,168 |
| Typesetting machines, linotype and others | 478,565 | 1,141,778 |
| Typewriting machines | 7,254,361 | 10,845,064 |
| Wood-working machinery: | | |
| Sawmills | 339,413 | 458,160 |
| All other | 1,026,446 | 884,410 |
| All other machinery, and parts of | 23,955,935 | 39,411,964 |
| Lead, manufactures of: | | |
| Pigs, bars, etc | 7,928,518 | 13,494,065 |
| All other manufactures of | 2,270,897 | 2,522,416 |
| Lime | 106,312 | 132,769 |
| Mica manufactures | 33,915 | 74,127 |
| Nickel, nickel oxide, and matte | 10,128,514 | 12,952,493 |
| Manufactures of | ..... | 1,674,600 |
| Petroleum products: | | |
| Gasoline and naphtha | 33,885,047 | 68,660,881 |
| Illuminating | 49,988,597 | 55,862,906 |
| Gas oil and fuel oil | [a] 21,961,176 | [a] 26,990,552 |
| Lubricating and heavy paraffin oil | 32,459,641 | 43,027,371 |
| Jelly, etc | 1,034,254 | 1,241,144 |
| Paraffin and paraffin wax | 12,535,430 | 14,820,440 |
| Residuum | 364,381 | 149,658 |
| Platinum, manufactures of | ..... | 83,864 |
| Stone (including marble): | | |
| Grindstones | 128,879 | 176,563 |
| All other manufactures of | 635,614 | 1,077,447 |
| Roofing slate | 46,137 | 27,630 |
| Tin and manufactures of: | | |
| Pigs, and oxide of | ..... | 395,206 |
| Scrap | ..... | 4,957 |
| Manufactures of | 2,496,291 | 3,375,746 |

[a] Does not include fuel or bunker oil laden on vessels engaged in the foreign trade which aggregated in value for the 12 months ending December, 1915, $3,161,341, and for the 12 months ending December, 1916, $5,583,222.

*Value of exports of products of the mine and manufactures of mine products for the calendar years 1915 and 1916*—Continued.

| | 1915 | 1916 |
|---|---|---|
| **Manufactured products**—Continued. | | |
| Zinc, manufactures of: | | |
| Dross | $506,956 | $10,801 |
| Spelter cast in pigs, bars, plates, and sheets | 29,537,680 | 51,312,990 |
| All other manufactures of | 2,173,089 | 572,286 |
| Zinc oxide | 2,068,428 | 2,394,739 |
| Total manufactured products | 842,493,261 | 1,690,303,256 |
| Increase | | 847,809,995 |
| Percentage of increase | | 100.64 |
| Total value of mine products (manufactured and unmanufactured): | | |
| Imports— | | |
| Metallic | 137,083,895 | 240,136,735 |
| Nonmetallic | 96,418,916 | 145,206,816 |
| Exports— | | |
| Metallic | 678,455,641 | 1,462,709,750 |
| Nonmetallic | 237,316,308 | 315,656,721 |
| Grand total imports | 233,502,811 | 385,343,551 |
| Increase | | 151,840,740 |
| Percentage of increase | | 65.03 |
| Grand total exports | 915,771,949 | 1,778,366,471 |
| Increase | | 862,594,522 |
| Percentage of increase | | 94.20 |
| Excess of exports over imports | 682,269,138 | 1,393,022,920 |

If gold and silver are included, for the sake of rounding out the metals mentioned in this report, the metallic imports increased from $623,522,439 in 1915 to $958,390,258 in 1916, and the metallic exports increased from $763,480,443 in 1915 to $1,689,097,714 in 1916; the total imports increased from $233,502,811 in 1915 to $385,343,551 in 1916, and the total exports increased from $915,771,949 in 1915 to $1,778,366,471 in 1916. The movements of gold and silver, however, are rather financial than commercial.

## PRODUCTION BY STATES.

In the following tables are shown (1) the value of the mineral production of the United States in 1916 arranged by minerals in order of value, with the States leading in the production of each mineral, and the percentage which each mineral represents of the total value for the entire country, and (2) the quantity and value of the principal metals, fuels, and structural materials in 1915 and 1916 arranged in groups in order of value in 1916, with States leading in the production of each mineral, and with the increase or decrease by minerals and by groups in 1916.

It is of interest to note that more than 57 per cent of the total value of mineral production may be credited to coal, pig iron, and copper, and that with the addition of petroleum these minerals yielded two-thirds of the entire value. Pennsylvania was the leading State in the production of 11 mineral products and California of 8, and no other State led in the production of more than 4 minerals. Coal was the product of greatest value in 16 States in 1916. The leading States in value of output in 1916 were as follows: Pennsylvania, Arizona, West Virginia, Oklahoma, Illinois, Ohio, Montana, and Michigan; 1915, Pennsylvania, West Virginia, Illinois, Ohio, California, Michigan, Arizona, and Montana.

*Mineral products of the United States in 1916, in order of value.*

| Rank. | Mineral. | Principal producing States (in order of value).[a] | Value. | Percentage of total for United States. |
|---|---|---|---|---|
| 1 | Coal: | | | |
| | Bituminous | Pennsylvania, West Virginia, Illinois, Ohio | $665,116,077 | 18.93 |
| | Pennsylvania anthracite. | Pennsylvania | 202,009,561 | 5.75 |
| 2 | Iron, pig | Pennsylvania, Ohio, Illinois, New York | 663,478,118 | 18.88 |
| 3 | Copper | Arizona, Montana, Michigan, Utah | 474,288,000 | 13.50 |
| 4 | Petroleum | Oklahoma, California, Illinois, Texas | 330,899,868 | 9.42 |
| 5 | Clay products | Ohio, Pennsylvania, New Jersey, Illinois | 207,200,091 | 5.90 |
| 6 | Iron ore | Minnesota, Michigan, Alabama, New York | [b]181,902,377 | [b]5.18 |
| 7 | Coke | Pennsylvania, Indiana, Alabama, Illinois | [b]170,841,197 | [b]4.86 |
| 8 | Zinc | Missouri, New Jersey, Montana, Colorado | 151,005,000 | 4.30 |
| 9 | Natural gas | West Virginia, Pennsylvania, Ohio, Oklahoma. | 120,227,468 | 3.42 |
| 10 | Cement | Pennsylvania, Indiana, California, Missouri | 104,689,090 | 2.98 |
| 11 | Gold | California, Colorado, Alaska, Nevada | 92,590,300 | 2.63 |
| 12 | Stone | Pennsylvania, Ohio, Vermont, New York | 79,041,699 | 2.25 |
| 13 | Lead (refined) | Missouri, Idaho, Utah, Colorado | 76,207,000 | 2.17 |
| 14 | Ferroalloys | Pennsylvania, Maryland, Illinois, Ohio | 50,281,692 | 1.43 |
| 15 | Silver | Montana, Nevada, Utah, Idaho | 48,953,000 | 1.39 |
| 16 | Aluminum | New York, Tennessee, North Carolina | 33,900,000 | .96 |
| 17 | Sand and gravel | Pennsylvania, Ohio, New York, Illinois | 29,809,995 | .85 |
| 18 | Mineral paints (zinc and lead pigments). | Pennsylvania, Wisconsin, Missouri, Kansas | 23,515,803 | .67 |
| 19 | Lime | Pennsylvania, Ohio, Virginia, Wisconsin | 18,509,305 | .53 |
| 20 | Natural-gas gasoline | Oklahoma, West Virginia, California, Pennsylvania. | 14,331,148 | .41 |
| 21 | Sulphuric acid from copper and zinc smelters. | Illinois, California, Ohio, Pennsylvania | 14,099,927 | .40 |
| 22 | Salt | Michigan, New York, Ohio, Kansas | 13,645,947 | .39 |
| 23 | Tungsten ore (60 per concentrates). | Colorado, California, Nevada, South Dakota | 12,074,000 | .34 |
| 24 | Gypsum | Iowa, New York, Michigan, Ohio | 7,959,032 | .22 |
| 25 | Asphalt | California, Texas, Oklahoma, Illinois | 7,102,132 | .20 |
| 26 | Phosphate rock | Florida, Tennessee, South Carolina, Kentucky | 5,896,993 | .17 |
| 27 | Clay, raw | Pennsylvania, Missouri, New Jersey, Georgia | [b]5,751,774 | [b].16 |
| 28 | Mineral waters | Wisconsin, New York, California, Maine | 5,735,035 | .16 |
| 29 | Slate | Pennsylvania, Vermont, Maine, Virginia | 5,338,837 | .15 |
| 30 | Antimonial lead | Not separable by States | 4,483,582 | .13 |
| 31 | Potash ($K_2O$) | Nebraska, California, Utah, Michigan | 4,242,730 | .12 |
| 32 | Quicksilver | California, Texas, Nevada, Oregon | 3,768,139 | .11 |
| 33 | Borax (crude) | California | 2,409,459 | |
| 34 | Platinum and allied metals. | California, Nevada, Wyoming, Oregon | 2,301,762 | |
| 35 | Bauxite | Arkansas, Georgia, Alabama, Tennessee | 2,296,400 | |
| 36 | Talc and soapstone | New York, Virginia, Vermont, Georgia | 2,253,803 | |
| 37 | Manganiferous ore | Minnesota, Nevada, Colorado, Virginia | 2,005,491 | |
| 38 | Pyrite | Virginia, California, New York, Illinois | 1,965,702 | |
| 39 | Sand-lime brick | Michigan, Minnesota, Massachusetts, New York | 1,474,073 | |
| 40 | Magnesite (crude) | California, Washington | 1,393,693 | |
| 41 | Barytes (crude) | Georgia, Missouri, Tennessee, Kentucky | 1,011,232 | |
| 42 | Bromine | Michigan, West Virginia, Ohio | 951,932 | |
| 43 | Graphite | Alabama, New York, Pennsylvania, Montana | 935,471 | |
| 44 | Fluorspar | Illinois, Kentucky, Colorado, New Hampshire | 922,654 | |
| 45 | Grindstones and pulpstones. | Ohio, Michigan, West Virginia | 766,140 | |
| 46 | Chromic iron ore | California, Oregon, Maryland, Wyoming | 726,243 | .77 |
| 47 | Fuller's earth | Florida, Georgia, Arkansas, Texas | 706,951 | |
| 48 | Feldspar | Maine, Maryland, New York, North Carolina | 702,278 | |
| 49 | Nickel | Not separable by States | 671,192 | |
| 50 | Manganese ore | Arkansas, California, Virginia, Arizona | 627,417 | |
| 51 | Mica | North Carolina, New Hampshire, South Dakota, Virginia. | 594,391 | |
| 52 | Arsenious oxide | Not separable by States | 555,187 | |
| 53 | Uranium and vanadium minerals. | Colorado, Utah | 500,000 | |
| 54 | Asbestos | Arizona, Georgia, California, Idaho | 448,214 | |
| 55 | Peat | Not separable by States | 369,104 | |
| 56 | Silica (quartz) | Wisconsin, Connecticut, New York, Maryland | 242,786 | |
| 57 | Diatomaceous (infusorial) earth and tripoli. | California, Missouri, Illinois, Pennsylvania | [c]241,553 | |

[a] Rank of States in metal production (except pig iron) arranged according to mines reports, not smelter output.

[b] Not included in total value.

[c] Exclusive of considerable production for special uses which is included under last item ("Unspecified").

*Mineral products of the United States in 1916, in order of value*—Continued.

| Rank. | Mineral. | Principal producing States (in order of value). | Value. | Per centage of total for United States. |
|---|---|---|---|---|
| 58 | Gems and precious stones. | Montana, California, Nevada, Colorado | $217,793 | |
| 59 | Calcium chloride | Michigan, West Virginia, Ohio | 216,729 | |
| 60 | Cadmium | Not separable by States | 210,931 | |
| 61 | Garnet for abrasive purposes. | New York, North Carolina, New Hampshire | 208,850 | |
| 62 | Oilstones, etc. | Arkansas, Indiana, Ohio, New Hampshire | 154,573 | 0.04 |
| 63 | Emery | New York | 123,901 | |
| 64 | Tin | Alaska, North Carolina | 122,000 | |
| 65 | Pumice | Kansas, Nebraska, California | 82,263 | |
| 66 | Millstones | Virginia, New York, North Carolina, Pennsylvania. | 44,559 | |
| 67 | Titanium ore (rutile) | Virginia | 16,500 | |
| 68 | Thorium minerals (monazite). | North Carolina, Florida | 3,400 | |
| | Total estimated value of "Unspecified" products. | | 15,000,000 | .43 |
| | Grand total | Pennsylvania, Arizona, West Virginia, Oklahoma, Illinois, Ohio. | 3,513,934,196 | 100.00 |

*Principal metals, fuels, and structural materials produced in the United States, 1915 and 1916.*

| Mineral. | Principal producing States in 1916 (in order of value).[a] | 1915 | | | 1916 | | | Increase or decrease in value. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | By minerals. | | By groups. | |
| | | Quantity. | Value. | Value by groups. | Quantity. | Value. | Value by groups. | Amount. | Percentage. | Amount. | Percentage. |
| **Metals (from domestic ores):** | | | | | | | | | | | |
| Pig iron, long tons | Pennsylvania, Ohio, Illinois, New York. | 29,439,464 | $388,397,654 | | 38,361,474 | $647,481,362 | | +$259,083,708 | +67 | | |
| Copper...pounds | Arizona, Montana, Michigan, Utah. | 1,388,009,527 | 242,902,000 | | 1,927,850,548 | 474,288,000 | | + 231,386,000 | +95 | | |
| Zinc...short tons | Missouri, New Jersey, Montana, Colorado. | 458,135 | 113,617,000 | | 563,451 | 151,005,000 | | + 37,388,000 | +33 | | |
| Gold, troy ounces | California, Colorado, Alaska, Nevada. | 4,887,602 | 101,035,700 | $931,009,654 | 4,479,056 | 92,590,300 | $1,490,524,662 | − 8,445,400 | − 8 | +$559,515,008 | +60 |
| Lead...short tons | Missouri, Idaho, Utah, Colorado. | 507,026 | 47,660,000 | | 552,228 | 76,207,000 | | + 28,547,000 | +60 | | |
| Silver, troy ounces | Montana, Nevada, Utah, Idaho. | 74,961,075 | 37,397,300 | | 74,414,802 | 48,953,000 | | + 11,555,700 | +31 | | |
| **Fuels:** | | | | | | | | | | | |
| Coal...short tons | Pennsylvania, West Virginia, Illinois, Ohio. | 531,619,487 | 686,691,186 | | 590,098,175 | 867,125,638 | | + 180,434,452 | +26 | | |
| Petroleum, barrels | Oklahoma, California, Illinois, Texas. | 281,104,104 | 179,462,890 | 967,466,457 | 300,767,158 | 330,899,868 | 1,318,252,974 | + 151,436,978 | +84 | +350,786,517 | +36 |
| Natural gas | West Virginia, Pennsylvania, Ohio, Oklahoma. | ..... | 101,312,381 | | ..... | 120,227,468 | | + 18,915,087 | +19 | | |
| **Structural materials:** | | | | | | | | | | | |
| Clay products (brick and tile). | Pennsylvania, Ohio, Illinois, New Jersey. | ..... | 125,794,844 | | ..... | 159,042,849 | | + 33,248,005 | +26 | | |
| Cement...barrels | Pennsylvania, Indiana, California, Missouri. | 87,685,222 | 75,155,102 | | 95,394,433 | 104,689,090 | | + 29,533,988 | +39 | | |
| Stone | Pennsylvania, Ohio, Vermont, New York. | ..... | 74,595,352 | | ..... | 79,041,699 | | + 4,446,347 | + 6 | | |
| Sand and gravel, ...short tons. | Pennsylvania, Ohio, New York, Illinois. | 76,603,303 | 23,121,617 | 324,646,759 | 89,091,732 | 29,809,995 | 404,390,807 | + 6,688,378 | +29 | + 79,744,048 | +25 |
| Lime.....do | Pennsylvania, Ohio, Virginia, Wisconsin. | 3,622,810 | 14,424,036 | | 4,073,433 | 18,509,305 | | + 4,085,269 | +28 | | |
| Gypsum....do | Iowa, New York, Michigan, Ohio. | 2,447,611 | 6,596,893 | | 2,757,730 | 7,959,032 | | + 1,362,139 | +21 | | |
| Slate | Pennsylvania, Vermont, Maine, Virginia. | ..... | 4,958,915 | | ..... | 5,338,837 | | + 379,922 | + 8 | | |

[a] Rank of States in metal production (except pig iron) arranged according to mines reports, not smelter output.

The following tables show (1) the value of the mineral production of the United States in 1915 and 1916, arranged by States in order of productive value in 1916, with leading products in each State, increase or decrease in each State, and percentage of total for the United States represented by each State in 1916; (2) value of mineral production by States, arranged alphabetically, from 1911 to 1916; and (3) table of production for each State alphabetically for 1915 and 1916, giving quantity and value of each mineral produced in the State and total value of the State's output.

Increases, ranging from 6.3 per cent in Massachusetts to 127 per cent in Nebraska, were recorded in all States except New Hampshire and Rhode Island and the District of Columbia, in which decreases of 4.7, 7.7, and 12.7 per cent, respectively, were shown. In addition to Nebraska, Arizona and Oklahoma more than doubled their 1915 production, and Montana, Minnesota, Utah, New Jersey, Texas, Louisiana, and Wyoming showed increases of more than 50 per cent. The eight leading States are credited with 56.4 per cent of the total value, as compared with 56.8 per cent in 1915.

Pennsylvania, contributing $573,978,305, or 19 per cent of the value of the country's entire mineral output, continues to lead all other States. Coal was the product of greatest value in Pennsylvania, and amounted to $423,694,736, or 74 per cent of the State's total, while the fuels, coal, natural gas, and petroleum, contributed 81 per cent. Arizona, ranking seventh in 1915, was second in 1916 with a total value of $192,622,991. The great increase in the value of Arizona's mineral output was due almost entirely to the greater production and higher value of copper, which represented 92 per cent of the State's total value. West Virginia was third in 1916 with a total value of $187,043,011, 92 per cent of which was the value of the fuels. Oklahoma, which was ninth in 1915, rose to fourth place in 1916 and made a mineral production valued at $169,595,752, of which the fuels contributed $147,973,006, or 87 per cent.

For more detailed accounts of the products the reader should consult the chapters of Mineral Resources on the different minerals.

*Rank of States in value of mineral production in 1915 and 1916.*

| State. | Principal mineral products in 1916 (in order of value). [a] | 1915 | | 1916 | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Rank. | Value. | Rank. | Value. | Increase or decrease. | Percentage of increase or decrease. | Percentage of total for United States. |
| Pennsylvania | Coal, clay products, cement, natural gas | 1 | $460,673,133 | 1 | $573,978,305 | +$113,305,172 | + 24.6 | 19.0 |
| Arizona | Copper, silver, gold, zinc | 7 | 91,552,049 | 2 | 192,622,991 | + 101,070,942 | + 110.4 | 6.4 |
| West Virginia | Coal, natural gas, petroleum, clay products | 2 | 136,070,173 | 3 | 187,043,011 | + 50,972,838 | + 37.5 | 6.2 |
| Oklahoma | Petroleum, natural gas, zinc, coal | 9 | 83,672,991 | 4 | 169,595,752 | + 85,922,761 | + 102.7 | 5.6 |
| Illinois | Coal, petroleum, clay products, cement | 3 | 114,446,161 | 5 | 146,780,236 | + 32,334,075 | + 28.3 | 4.9 |
| Ohio | Coal, clay products, petroleum, natural gas | 4 | 105,198,086 | 6 | 145,080,217 | + 39,882,131 | + 37.9 | 4.8 |
| Montana | Copper, zinc, silver, coal | 8 | 89,147,138 | 7 | 142,650,179 | + 53,503,041 | + 60.0 | 4.8 |
| Michigan | Copper, iron ore, cement, salt | 6 | 93,938,255 | 8 | 140,666,124 | + 46,727,869 | + 49.7 | 4.7 |
| California | Petroleum, gold, copper, cement | 5 | 98,198,538 | 9 | 136,756,058 | + 38,557,520 | + 39.3 | 4.6 |
| Minnesota | Iron ore, clay products, stone, cement | 13 | 62,391,440 | 10 | 113,662,522 | + 51,271,082 | + 82.2 | 3.8 |
| Missouri | Zinc, lead, coal, clay products | 10 | 74,953,623 | 11 | 103,526,424 | + 28,572,801 | + 38.1 | 3.4 |
| Utah | Copper, lead, silver, coal | 12 | 62,586,261 | 12 | 99,734,209 | + 37,147,948 | + 59.4 | 3.3 |
| Colorado | Gold, zinc, coal, silver | 11 | 64,300,026 | 13 | 77,570,478 | + 13,270,452 | + 20.6 | 2.6 |
| New Jersey | Zinc, clay products, cement, iron ore | 15 | 38,818,422 | 14 | 61,114,525 | + 22,296,103 | + 57.4 | 2.0 |
| Indiana | Coal, cement, clay products, stone | 14 | 41,381,456 | 15 | 56,918,342 | + 15,536,886 | + 37.5 | 1.9 |
| Nevada | Copper, silver, gold, zinc | 17 | 35,991,891 | 16 | 53,510,559 | + 17,518,668 | + 48.7 | 1.8 |
| Idaho | Lead, zinc, silver, copper | 18 | 33,612,194 | 17 | 49,249,134 | + 15,636,940 | + 46.5 | 1.6 |
| Alaska | Copper, gold, silver, stone | 19 | 32,854,011 | 18 | 48,521,513 | + 15,667,502 | + 47.7 | 1.6 |
| Texas | Petroleum, sulphur, cement, natural gas | 22 | 29,220,951 | 19 | 47,711,571 | + 18,490,620 | + 63.3 | 1.6 |
| New York | Clay products, cement, iron ore, stone | 16 | 36,414,038 | 20 | 45,783,230 | + 9,369,192 | + 25.7 | 1.5 |
| Kansas | Coal, petroleum, natural gas, cement | 21 | 29,350,974 | 21 | 42,767,815 | + 13,416,841 | + 45.7 | 1.4 |
| Alabama | Coal, iron ore, clay products, cement | 20 | 29,458,157 | 22 | 40,922,462 | + 11,464,305 | + 38.9 | 1.4 |
| Kentucky | Coal, clay products, petroleum, stone | 23 | 27,278,627 | 23 | 39,989,007 | + 12,710,380 | + 46.6 | 1.3 |
| New Mexico | Copper, coal, zinc, gold | 25 | 25,549,161 | 24 | 37,123,501 | + 11,574,340 | + 45.3 | 1.2 |
| Iowa | Coal, clay products, cement, gypsum | 24 | 27,048,177 | 25 | 30,210,284 | + 3,162,107 | + 11.7 | 1.0 |
| Wisconsin | Zinc, iron ore, stone, mineral waters | 27 | 19,795,588 | 26 | 28,304,675 | + 8,509,087 | + 43.0 | .9 |
| Tennessee | Coal, zinc, copper, clay products | 26 | 22,166,494 | 27 | 28,277,365 | + 6,110,871 | + 27.6 | .9 |
| Louisiana | Petroleum, sulphur, natural gas, sand and gravel | 28 | 18,215,847 | 28 | 28,020,543 | + 9,804,696 | + 53.8 | .9 |
| Virginia | Coal, clay products, stone, lime | 29 | 16,994,786 | 29 | 20,560,956 | + 3,566,170 | + 21.0 | .7 |
| Wyoming | Coal, petroleum, copper, iron ore | 30 | 12,708,238 | 30 | 19,666,988 | + 6,958,750 | + 54.8 | .7 |
| Washington | Coal, cement, clay products, stone | 31 | 11,455,715 | 31 | 14,521,014 | + 3,065,299 | + 26.8 | .5 |
| Maryland | Coal, clay products, cement, stone | 32 | 10,581,224 | 32 | 13,335,013 | + 2,753,789 | + 26.0 | .5 |
| Arkansas | Coal, bauxite, zinc, clay products | 35 | 6,558,693 | 33 | 9,538,933 | + 2,980,240 | + 45.4 | .3 |
| South Dakota | Gold, tungsten ore, stone, silver | 33 | 8,093,670 | 34 | 8,696,680 | + 603,010 | + 7.5 | .3 |
| Vermont | Stone, slate, talc and soapstone, lime | 34 | 7,586,410 | 35 | 8,258,848 | + 672,438 | + 8.9 | .3 |
| Georgia | Clay products, stone, cement, iron ore | 37 | 5,094,688 | 36 | 6,779,828 | + 1,685,140 | + 33.1 | .2 |
| Massachusetts | Stone, clay products, lime, sand and gravel | 36 | 6,286,860 | 37 | 6,683,844 | + 396,984 | + 6.3 | .2 |
| Florida | Phosphate rock, fuller's earth, stone, clay products | 38 | 4,855,690 | 38 | 5,657,785 | + 802,095 | + 16.5 | .2 |

[a] In this table iron ore, not pig iron, is taken as the basis of iron valuation, and in the case of other metals mine production (recoverable content of metals) is the basis

*Rank of States in value of mineral production in 1915 and 1916*—Continued.

| State. | Principal mineral products in 1916 (in order of value). | 1915 | | 1916 | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Rank. | Value. | Rank. | Value. | Increase or decrease. | Percentage of increase or decrease. | Percentage of total for United States. |
| North Carolina | Stone, clay products, mica, iron ore | 40 | $3,365,805 | 39 | $4,595,551 | + $1,229,746 | + 36.5 | 0.2 |
| Oregon | Gold, copper, stone, clay products | 39 | 3,656,562 | 40 | 4,498,632 | + 842,070 | + 23.0 | .2 |
| Connecticut | Clay products, stone, lime, mineral waters | 41 | 3,332,330 | 41 | 3,940,676 | + 608,346 | + 18.3 | .1 |
| Maine | Stone, lime, clay products, mineral waters | 42 | 3,301,907 | 42 | 3,539,081 | + 237,174 | + 7.2 | .1 |
| Nebraska | Potash ($K_2O$), clay products, stone, sand and gravel | 44 | 1,514,171 | 43 | 3,436,774 | + 1,922,603 | + 127.0 | .1 |
| New Hampshire | Stone, clay products, mica, sand and gravel | 43 | 1,907,949 | 44 | 1,817,723 | − 90,226 | − 4.7 | |
| South Carolina | Clay products, stone, phosphate rock, mineral waters | 45 | 1,129,709 | 45 | 1,392,073 | + 262,364 | + 23.2 | |
| North Dakota | Coal, clay products, sand and gravel, sand-lime brick | 46 | 985,885 | 46 | 1,283,809 | + 297,924 | + 30.2 | |
| Mississippi | Clay products, sand and gravel, mineral waters | 48 | 666,143 | 47 | 890,566 | + 224,423 | + 33.7 | .3 |
| Rhode Island | Stone, clay products, mineral waters, lime | 47 | 855,007 | 48 | 789,208 | − 65,799 | − 7.7 | |
| Delaware | Clay products, stone, mineral waters, sand and gravel | 49 | 282,292 | 49 | 336,172 | + 53,880 | + 19.1 | |
| District of Columbia | Clay products, sand-lime brick, stone, mineral waters | 50 | 205,592 | 50 | 179,436 | − 26,156 | − 12.7 | |

*Value [a] of mineral production, 1911 to 1916, by States.*

| State. | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| Alabama | $28,005,785 | $30,641,983 | $34,660,545 | $30,879,288 | $29,458,157 | $40,922,462 |
| Alaska | 20,866,122 | 22,732,947 | 19,645,498 | 19,177,051 | 32,854,011 | 48,521,513 |
| Arizona | 44,503,873 | 67,497,838 | 71,429,705 | 60,420,362 | 91,552,049 | 192,622,991 |
| Arkansas | 5,864,822 | 6,258,726 | 6,780,760 | 5,787,199 | 6,558,693 | 9,538,933 |
| California | 90,620,644 | 93,219,149 | 100,791,369 | 101,013,199 | 98,198,538 | 136,756,058 |
| Colorado | 52,522,416 | 58,167,399 | 54,294,281 | 52,161,060 | 64,300,026 | 77,570,478 |
| Connecticut | 3,151,588 | 3,715,480 | 3,795,297 | 3,023,192 | 3,332,330 | 3,940,676 |
| Delaware | 491,057 | 425,360 | 541,542 | 288,516 | 282,292 | 336,172 |
| District of Columbia | 277,295 | 300,336 | 246,582 | 219,680 | 205,592 | 179,436 |
| Florida | 10,250,228 | 10,272,594 | 10,508,016 | 8,497,688 | 4,855,690 | 5,657,785 |
| Georgia | 6,172,857 | 6,306,140 | 6,525,792 | 5,704,856 | 5,044,688 | 6,779,828 |
| Idaho | 19,441,545 | 21,816,390 | 24,565,826 | 24,913,223 | 33,612,194 | 49,249,134 |
| Illinois | 100,275,115 | 123,068,867 | 131,825,221 | 117,166,370 | 114,446,161 | 146,780,236 |
| Indiana | 37,430,187 | 42,239,193 | 46,502,633 | 42,864,267 | 41,381,456 | 56,918,342 |
| Iowa | 21,112,996 | 22,900,350 | 25,602,015 | 26,287,115 | 27,048,177 | 30,210,284 |
| Kansas | 25,237,043 | 26,554,967 | 27,312,563 | 25,866,351 | 29,350,974 | 42,767,815 |
| Kentucky | 19,296,614 | 22,477,530 | 26,845,579 | 26,608,474 | 27,278,627 | 30,989,007 |
| Louisiana | 12,710,068 | 15,357,841 | 21,011,828 | 21,890,025 | 18,215,847 | 28,020,543 |
| Maine | 4,645,630 | 3,925,526 | 4,429,684 | 3,975,890 | 3,301,907 | 3,539,081 |
| Maryland | 9,386,515 | 10,851,671 | 11,292,723 | 10,587,564 | 10,581,224 | 13,335,013 |
| Massachusetts | 6,623,077 | 6,654,514 | 7,044,520 | 6,292,533 | 6,286,860 | 6,083,844 |
| Michigan | 65,275,924 | 80,062,486 | 72,143,211 | 57,743,555 | 93,938,255 | 140,666,124 |
| Minnesota | 53,395,981 | 66,672,729 | 85,814,533 | 45,680,965 | 62,391,440 | 115,662,522 |
| Mississippi | 1,052,842 | 1,242,528 | 1,143,472 | 1,104,197 | 666,143 | 890,566 |
| Missouri | 51,932,006 | 58,332,550 | 54,001,088 | 48,597,693 | 74,953,623 | 103,526,424 |
| Montana | 53,498,194 | 71,620,873 | 69,307,056 | 54,244,889 | 89,147,138 | 142,650,179 |
| Nebraska | 1,316,168 | 1,490,582 | 1,433,718 | 1,166,787 | 1,514,171 | 3,436,774 |
| Nevada | 34,501,832 | 39,111,828 | 37,842,084 | 29,984,338 | 35,991,891 | 53,510,559 |
| New Hampshire | 1,727,645 | 1,949,876 | 2,218,925 | 2,029,935 | 1,907,949 | 1,817,723 |
| New Jersey | 31,663,435 | 37,195,940 | 35,931,191 | 31,756,503 | 38,818,422 | 61,114,525 |
| New Mexico | 8,176,229 | 14,391,355 | 17,862,389 | 18,072,019 | 25,549,161 | 37,123,501 |
| New York | 34,317,894 | 38,431,910 | 41,709,002 | 36,420,134 | 36,414,038 | 45,783,230 |
| North Carolina | 2,793,925 | 3,368,923 | 3,739,696 | 3,519,245 | 3,365,805 | 4,595,551 |
| North Dakota | 957,425 | 1,025,741 | 1,055,676 | 1,063,540 | 985,885 | 1,283,809 |
| Ohio | 97,090,284 | 111,229,656 | 121,795,892 | 101,661,384 | 105,198,086 | 145,080,217 |
| Oklahoma | 43,036,253 | 53,614,130 | 80,168,829 | 78,744,447 | 83,672,991 | 169,595,752 |
| Oregon | 3,192,679 | 2,553,549 | 3,563,019 | 3,331,132 | 3,656,562 | 4,498,632 |
| Pennsylvania | 414,426,962 | 445,799,653 | 506,341,809 | 452,824,034 | 460,673,133 | 573,978,305 |
| Rhode Island | 1,253,656 | 942,842 | 813,952 | 777,716 | 855,007 | 789,208 |
| South Carolina | 1,803,579 | 1,606,989 | 1,464,150 | 1,414,394 | 1,129,709 | 1,392,073 |
| South Dakota | 8,047,259 | 8,436,240 | 7,909,059 | 7,861,001 | 8,093,670 | 8,696,680 |
| Tennessee | 17,899,982 | 19,362,209 | 21,008,038 | 19,647,145 | 22,166,494 | 28,277,365 |
| Texas | 18,798,837 | 22,797,015 | 31,666,010 | 30,363,426 | 29,220,951 | 47,711,571 |
| Utah | 43,774,331 | 51,004,942 | 53,606,520 | 45,636,198 | 62,586,261 | 90,734,209 |
| Vermont | 8,434,516 | 9,087,560 | 9,647,985 | 8,665,967 | 7,586,410 | 8,258,848 |
| Virginia | 13,713,566 | 14,995,842 | 17,178,580 | 16,400,347 | 16,994,786 | 20,560,956 |
| Washington | 15,865,377 | 15,347,313 | 17,579,743 | 13,830,739 | 11,455,715 | 14,521,014 |
| West Virginia | 101,932,248 | 123,847,812 | 143,591,372 | 133,633,229 | 136,070,173 | 187,043,011 |
| Wisconsin | 12,032,158 | 14,192,287 | 12,452,480 | 11,140,365 | 19,795,588 | 28,304,675 |
| Wyoming | 11,483,577 | 13,374,088 | 13,082,091 | 12,417,752 | 12,708,238 | 19,666,988 |

[a] In this table iron ore, not pig iron, is taken as the basis of iron valuation, and in the case of other metals mine production (recoverable content of metals) is the basis.

*Mineral production of Alabama in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Barytes.....short tons.. | (a) | (a) | 7,631 | $27,198 |
| Bauxite.....long tons.. | (a) | (a) | (a) | (a) |
| Cement.....barrels.. | 1,114,386 | $891,483 | 1,442,575 | 1,410,104 |
| Clay products..... | ..... | 1,193,022 | ..... | 1,520,301 |
| Clay, raw.....short tons.. | 31,870 | b 35,232 | 41,479 | b 51,053 |
| Coal.....do.... | 14,927,937 | 19,066,013 | 18,086,197 | 24,859,831 |
| Coke.....do.... | 3,071,811 | b 8,545,555 | 4,298,417 | b 15,019,139 |
| Ferroalloys.....long tons.. | (a b) | (a b) | 9,943 | (a b) |
| Gold.....fine ounces (troy).. | 254 | 5,243 | 418 | 8,650 |
| Graphite, crystalline.....pounds.. | 3,474,800 | 204,572 | 5,226,940 | 492,407 |
| Iron ore.....long tons.. | 5,134,955 | 6,798,266 | 6,801,839 | 10,843,231 |
| Iron, pig.....do.... | 2,320,255 | b 23,757,124 | 2,672,498 | b 38,994,660 |
| Lime.....short tons.. | 60,332 | 250,227 | 67,524 | 312,531 |
| Manganese ore.....long tons.. | 200 | (a) | (a) | (a) |
| Mica..... | ..... | 5,940 | ..... | 5,615 |
| Millstones..... | ..... | ..... | ..... | (a) |
| Mineral paints, natural pigments.....short tons.. | (a) | (a) | (c) | (c) |
| Mineral waters.....gallons sold.. | 86,499 | 8,912 | 103,944 | 12,174 |
| Natural gas..... | ..... | (a) | ..... | (a) |
| Sand and gravel.....short tons.. | 924,701 | 242,336 | 726,650 | 184,216 |
| Sand and sandstone (finely ground).....do.... | (a) | (a) | ..... | ..... |
| Silver.....fine ounces (troy).. | 12 | 6 | 53 | 35 |
| Stone..... | ..... | 719,452 | ..... | 1,202,256 |
| Miscellaneous..... | ..... | 640,903 | ..... | 1,529,744 |
| Total value, eliminating duplications..... | ..... | 29,458,157 | ..... | 40,922,462 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Canvass discontinued.

*Mineral production of Alaska in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons.. | 883 | $71,638 | 841 | $10,306 |
| Barytes.....do.... | (a) | (a) | ..... | ..... |
| Coal.....do.... | 1,900 | 3,300 | 13,073 | 52,347 |
| Copper.....pounds.. | 86,509,312 | 15,139,129 | 119,854,839 | 29,484,291 |
| Gems and precious stones..... | ..... | (a) | ..... | ..... |
| Gold.....fine ounces (troy).. | 807,966 | 16,702,144 | 834,068 | 17,241,713 |
| Gypsum.....short tons.. | (b) | (b) | (b) | (b) |
| Lead.....do.... | 437 | 41,118 | 820 | 113,160 |
| Petroleum.....barrels.. | (a) | (a) | (a) | (a) |
| Silver.....fine ounces (troy).. | 1,071,782 | 543,393 | 1,379,171 | 907,495 |
| Stone..... | ..... | (a) | ..... | (a) |
| Tin (metallic equivalent).....short tons.. | 102 | 78,846 | 139 | 120,874 |
| Tungsten ore (60 per cent concentrates).....do.... | (a) | (a) | 47 | 69,518 |
| Miscellaneous..... | ..... | 274,443 | ..... | 521,839 |
| [redacted], eliminating duplications..... | ..... | 32,854,011 | ..... | 48,521,513 |

a Value included under "Miscellaneous."
b Calcined in Washington State. Value included under "Miscellaneous."

*Mineral production of Arizona in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons | | | | $3 |
| Asbestos.....do | (a) | (a) | (a) | (a) |
| Clay products | | $97,208 | | 106,149 |
| Copper.....pounds | 459,972,295 | 80,495,152 | 721,833,169 | 177,570,960 |
| Fluorspar.....short tons | | | (a) | (a) |
| Gems and precious stones | | 4,998 | | 4,878 |
| Gold.....fine ounces (troy) | 201,531 | 4,166,025 | 192,801 | 3,985,559 |
| Gypsum.....short tons | (a) | (a) | (a) | (a) |
| Lead.....do | 10,869 | 1,021,732 | 13,531 | 1,867,284 |
| Lime.....do | 14,137 | 90,931 | 15,173 | 94,540 |
| Manganese ore.....long tons | 339 | (a) | 2,754 | 109,089 |
| Manganiferous ore.....do | 1,452 | (a) | 7,698 | 43,875 |
| Mineral paints, natural pigments.....short tons | (a) | (a) | (b) | (b) |
| Molybdenum.....pounds | 105,157 | 88,116 | 203,580 | 203,000 |
| Quicksilver.....flasks | (a) | (a) | (a) | (a) |
| Sand and gravel.....short tons | (a) | (a) | (a) | (a) |
| Silica (quartz).....do | (a) | (a) | (a) | (a) |
| Silver.....fine ounces (troy) | 5,649,020 | 2,884,053 | 7,212,039 | 4,745,522 |
| Stone | | 90,512 | | 300,579 |
| Strontium.....short tons | | | (a) | (a) |
| Tungsten ore (60 per cent concentrates).....do | 127 | 245,360 | 218 | 385,292 |
| Zinc.....do | 9,110 | 2,259,387 | 9,839 | 2,636,845 |
| Miscellaneous | | 128,575 | | 563,416 |
| Total value, eliminating duplications | | 91,552,049 | | 192,622,991 |

a Value included under "Miscellaneous."
b Canvass discontinued.

*Mineral production of Arkansas in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons | | | 250 | $1,236 |
| Bauxite.....long tons | 268,796 | $1,370,489 | 375,910 | 2,011,590 |
| Clay products | | 343,967 | | a 521,569 |
| Clay, raw.....short tons | (bc) | (bc) | (bc) | (bc) |
| Coal.....do | 1,652,106 | 2,950,456 | 1,994,915 | 3,836,845 |
| Fuller's earth.....do | (b) | (b) | (b) | (b) |
| Gems and precious stones | | 1,059 | | 2,250 |
| Iron ore for magnets.....long tons | 10 | (b) | 5 | (b) |
| Lead.....short tons | 63 | 5,922 | 272 | 37,536 |
| Lime.....do | 15,879 | 78,112 | 19,199 | 102,683 |
| Manganese ore.....long tons | 588 | 10,013 | 6,131 | 176,995 |
| Manganiferous ore.....do | 3,355 | 11,864 | 3,809 | 26,392 |
| Marl, calcareous.....short tons | | | (b) | (b) |
| Mineral waters.....gallons sold | 1,377,093 | 119,072 | 1,152,505 | 100,616 |
| Natural gas | | 193,092 | | 241,896 |
| Oilstones | | (b) | | (b) |
| Phosphate rock.....long tons | (b) | (b) | | |
| Sand and gravel.....short tons | 931,316 | 352,957 | 54[redacted] | [redacted]8 |
| Stone | | 255,681 | | [redacted]5 |
| Zinc.....short tons | 3,209 | 795,832 | 6,815 | 1,826,420 |
| Miscellaneous | | 82,281 | | 118,183 |
| Total value, eliminating duplications | | 6,558,693 | | 9,538,933 |

a Exclusive of pottery, value for which is included under "Miscellaneous."
b Value included under "Miscellaneous."
c Value not included in total value.

*Mineral production of California in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons | 2,208 | $187,680 | 899 | $3,159 |
| Asbestos.....do | (a) | (a) | (a) | (a) |
| Asphalt.....do | 256,711 | 1,578,464 | 276,065 | 2,004,048 |
| Barytes.....do | (a) | (a) | (a) | (a) |
| Borax.....do | 67,003 | 1,677,099 | 103,525 | 2,409,459 |
| Briquets, fuel.....do | (a b) | (a b) | (a b) | (a b) |
| Cement.....barrels | 4,532,452 | 6,338,918 | 5,216,324 | 7,407,290 |
| Chromic iron ore.....long tons | 3,281 | 36,744 | 43,758 | 682,937 |
| Clay products..... | ..... | 3,599,375 | ..... | 4,163,426 |
| Clay, raw.....short tons | 94,598 | b 118,130 | 106,330 | b 133,950 |
| Coal.....do | (a) | (a) | (a) | (a) |
| Copper.....pounds | 40,751,625 | 7,131,534 | 55,897,118 | 13,750,601 |
| Diatomaceous earth..... | ..... | (a) | ..... | (a) |
| Feldspar.....short tons | 2,004 | 9,550 | 1,400 | 6,550 |
| Ferroalloys.....long tons | (a b) | (a b) | (a b) | (a b) |
| Fuller's earth.....short tons | (a) | (a) | (a) | (a) |
| Gems and precious stones..... | ..... | 22,312 | ..... | 54,885 |
| Gold.....fine ounces (troy) | 1,085,646 | 22,442,296 | 1,035,745 | 21,410,741 |
| Graphite, crystalline.....pounds | ..... | ..... | (a) | (a) |
| Gypsum.....short tons | 32,559 | 113,863 | 32,575 | 109,061 |
| Iron ore.....long tons | 646 | 2,584 | 2,970 | 11,880 |
| Iron, pig.....do | ..... | ..... | 154 | (a b) |
| Lead.....short tons | 2,290 | 215,225 | 6,204 | 856,117 |
| Lime.....do | 57,292 | 431,424 | 56,820 | 393,930 |
| Lithium minerals.....do | (a) | (a) | (a) | (a) |
| Magnesite.....do | 30,499 | 274,491 | 154,259 | 1,388,331 |
| Manganese ore.....long tons | 2,563 | 29,004 | 6,054 | 122,409 |
| Manganiferous ore.....do | ..... | ..... | 221 | (a) |
| Marl, calcareous.....short tons | ..... | ..... | (a) | (a) |
| Mineral paints, natural pigments.....short tons | 402 | 4,403 | (c) | (c) |
| Mineral waters.....gallons sold | 2,789,871 | 532,817 | 2,651,471 | 503,775 |
| Molybdenum.....pounds | ..... | ..... | 666 | 700 |
| Natural gas..... | ..... | 4,089,004 | ..... | 5,440,277 |
| Natural-gas gasoline.....gallons | 12,835,126 | 975,397 | 17,158,754 | 2,293,822 |
| Pebbles for grinding.....short tons | ..... | ..... | 6,000 | 36,000 |
| Petroleum.....barrels | 86,591,535 | 36,558,439 | 90,951,936 | 53,702,733 |
| Platinum and allied metals.....fine ounces (troy) | 457 | 25,135 | 687 | 55,979 |
| Potash ($K_2O$).....short tons | ..... | ..... | 3,823 | 1,403,199 |
| Pumice.....do | (a) | (a) | (a) | (a) |
| Pyrite.....long tons | 132,270 | 496,111 | 145,762 | 565,699 |
| Quicksilver.....flasks | 14,283 | 1,225,481 | 21,045 | 2,649,355 |
| Salt.....short tons | 146,784 | 694,070 | 157,393 | 656,975 |
| Sand and gravel.....do | 3,827,706 | 977,116 | 4,489,498 | 1,036,085 |
| Sand-lime brick..... | ..... | 12,158 | ..... | d 3,337 |
| Silica (quartz).....short tons | 3,620 | 19,602 | 5,648 | 11,533 |
| Silver.....fine ounces (troy) | 1,678,756 | 851,129 | 2,564,354 | 1,687,345 |
| Slate..... | ..... | ..... | ..... | (a) |
| Stone..... | ..... | 3,516,079 | ..... | 3,133,305 |
| Strontium.....short tons | ..... | ..... | (a) | (a) |
| Sulphuric acid (60° Baumé) e.....do | (a) | (a) | (a) | (a) |
| Talc and soapstone.....do | 712 | 7,185 | 685 | 10,969 |
| Tungsten ore (60 per cent concentrates).....do | 962 | 1,005,467 | 2,171 | 4,098,999 |
| Volcanic ash..... | ..... | ..... | ..... | 967 |
| Zinc.....do | 6,547 | 1,623,660 | 7,628 | 2,044,369 |
| Miscellaneous..... | ..... | 1,719,183 | ..... | 3,763,104 |
| Total value, eliminating duplications..... | ..... | 98,198,538 | ..... | 136,756,058 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Canvass discontinued.
d Exclusive of fancy brick, value for which is included under "Miscellaneous."
e From copper smelting.

*Mineral production of Colorado in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asphalt.....short tons.. | (a) | (a) | (a) | (a) |
| Barytes.....do.... | | | 481 | $3,005 |
| Briquets, fuel.....do.... | | | (a b) | (a b) |
| Cement.....barrels.. | (a) | (a) | (a) | (a) |
| Clay products..... | | $1,265,105 | | 1,930,039 |
| Clay, raw.....short tons.. | 71,113 | b 68,180 | 76,986 | b 77,830 |
| Coal.....do.... | 8,624,980 | 13,509,264 | 10,484,237 | 16,964,104 |
| Coke.....do.... | 670,938 | b 2,242,453 | 1,053,553 | b 3,736,467 |
| Copper.....pounds.. | 7,112,537 | 1,244,694 | 8,624,081 | 2,121,524 |
| Ferroalloys.....long tons.. | (a b) | (a b) | (a b) | (a b) |
| Fluorspar.....short tons.. | (a) | (a) | (a) | (a) |
| Gems and precious stones..... | | 5,987 | | 10,818 |
| Gold.....fine ounces (troy).. | 1,084,323 | 22,414,944 | 926,566 | 19,153,821 |
| Graphite, amorphous.....short tons.. | | | (a) | (a) |
| Gypsum.....do.... | (a) | (a) | (a) | (a) |
| Iron ore.....long tons.. | (a) | (a) | (a) | (a) |
| Iron, pig.....do.... | (a b) | (a b) | 367,629 | (a b) |
| Lead.....short tons.. | 34,405 | 3,234,098 | 35,457 | 4,893,072 |
| Lime.....do.... | 4,647 | 29,131 | 5,479 | 36,473 |
| Manganese ore.....long tons.. | 150 | (a) | 110 | 1,670 |
| Manganiferous ore.....do.... | 30,921 | 61,129 | 107,113 | 318,027 |
| Mica..... | | | | (a) |
| Mineral waters.....gallons sold.. | 858,185 | 63,104 | 542,185 | 120,509 |
| Molybdenum.....pounds.. | (a) | (a) | | |
| Natural gas..... | | (a) | | (a) |
| Natural-gas gasoline.....gallons.. | (a) | (a) | (a) | (a) |
| Petroleum.....barrels.. | 208,475 | 183,485 | 197,235 | 217,139 |
| Sand and gravel.....short tons.. | (a) | (a) | 244,208 | 93,259 |
| Sand and sandstone (finely ground).....do.... | (a) | (a) | | |
| Silica (quartz).....do.... | | | (a) | (a) |
| Silver.....fine ounces (troy).. | 7,027,972 | 3,563,182 | 7,656,544 | 5,038,006 |
| Stone..... | | 1,425,270 | | 975,794 |
| Sulphuric acid c.....short tons.. | (a) | (a) | (a) | (a) |
| Tungsten ore (60 per cent concentrates).....do.... | 963 | 2,311,200 | 2,401 | 4,606,301 |
| Uranium and vanadium ores..... | | 692,810 | | 490,000 |
| Zinc.....short tons.. | 52,297 | 12,969,779 | 67,143 | 17,994,252 |
| Miscellaneous..... | | 5,139,309 | | 8,964,282 |
| Total value, eliminating duplications..... | | 64,300,026 | | 77,570,478 |

a Value included under "Miscellaneous."
b Value not included in total value.
c From zinc smelting.

*Mineral production of Connecticut in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products..... | | $1,529,216 | | $1,865,329 |
| Clay, raw.....short tons.. | (a b) | (a b) | (a b) | (a b) |
| Diatomaceous earth..... | | (a) | | (a) |
| Feldspar.....short tons.. | 13,510 | 73,124 | 12,333 | 76,979 |
| Gems and precious stones..... | | 68 | | (a) |
| Iron ore.....long tons.. | (a) | (a) | (a) | (a) |
| Iron, pig.....do.... | (a b) | (a b) | 4,978 | (a b) |
| Lime.....short tons.. | 76,022 | 368,343 | 85,063 | 599,257 |
| Mica..... | | (a) | | (a) |
| Mineral waters.....gallons sold.. | 1,774,213 | 101,970 | 2,837,878 | 133,768 |
| Sand and gravel.....short tons.. | 19,350 | 5,137 | 89,682 | 53,040 |
| Sand-lime brick..... | | (a) | | (a) |
| Silica (quartz).....short tons.. | (a) | (a) | (a) | (a) |
| Stone..... | | 1,134,947 | | 1,143,011 |
| Tungsten ore (60 per cent concentrates).....short tons.. | (a) | (a) | 3 | 8,400 |
| Miscellaneous..... | | 255,118 | | 235,348 |
| Total value, eliminating duplications..... | | 3,332,330 | | 3,940,676 |

a Value included under "Miscellaneous."
b Value not included in total value.

*Mineral production of Delaware in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products | | $145,694 | | $187,388 |
| Clay, raw, short tons | 10,148 | [a] 61,789 | 12,844 | [a] 101,384 |
| Mineral waters, gallons sold | [b] | [b] | [b] | [b] |
| Sand and gravel, short tons | [b] | [b] | 9,487 | 9,721 |
| Stone | | 131,379 | | 121,354 |
| Miscellaneous | | 5,219 | | 17,709 |
| Total value, eliminating duplications | | 282,292 | | 336,172 |

[a] Value not included in total value.
[b] Value included under "Miscellaneous."

*Mineral production of the District of Columbia in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products | | [a] $131,134 | | [a] $129,394 |
| Mineral waters, gallons sold | | | [b] | [b] |
| Sand and gravel, short tons | [b] | [b] | | |
| Sand-lime brick | | [b] | | [b] |
| Stone | | 5,775 | | 3,315 |
| Miscellaneous | | 68,683 | | 46,727 |
| Total value, eliminating duplications | | 205,592 | | 179,436 |

[a] Exclusive of pottery, value for which is included under "Miscellaneous."
[b] Value included under "Miscellaneous."

*Mineral production of Florida in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products | | $203,414 | | $226,362 |
| Clay, raw, short tons | [a b] | [a b] | [a b] | [a b] |
| Fuller's earth, do | [a] | [a] | [a] | [a] |
| Lime, do | 9,243 | 47,920 | 8,666 | 49,536 |
| Mineral waters, gallons sold | 118,920 | 12,516 | 202,970 | 15,676 |
| Monazite sand, pounds | | | [a] | [a] |
| Phosphate rock, long tons | 1,358,611 | 3,762,239 | 1,515,845 | 4,170,165 |
| Sand and gravel, short tons | 123,548 | 34,055 | 86,452 | 42,352 |
| Sand-lime brick | | 77,575 | | 90,794 |
| Stone | | 354,673 | | 479,837 |
| Miscellaneous | | 512,298 | | 785,099 |
| Total value, eliminating duplications | | 4,855,690 | | 5,657,785 |

[a] Value included under "Miscellaneous."
[b] Value not included in total value.

*Mineral production of Georgia in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asbestos.....short tons.. | (a) | (a) | (a) | (a) |
| Barytes:.....do.... | 31,027 | $102,825 | 104,784 | $401,295 |
| Bauxite.....long tons.. | (a) | (a) | 40,388 | 239,089 |
| Cement.....barrels.. | (a) | (a) | (a) | (a) |
| Clay products..... | ..... | 1,845,019 | ..... | 2,361,982 |
| Clay, raw.....short tons.. | 166,250 | b 319,465 | 193,791 | b 443,147 |
| Coal.....do.... | 134,496 | 231,861 | 173,554 | 310,093 |
| Coke.....do.... | 20,039 | b 81,170 | 47,127 | b 232,630 |
| Copper.....pounds.. | ..... | ..... | 803,699 | 197,710 |
| Feldspar.....short tons.. | ..... | ..... | (a) | (a) |
| Fuller's earth.....do.... | (a) | (a) | (a) | (a) |
| Gold.....fine ounces (troy).. | 1,733 | 35,821 | 1,090 | 22,539 |
| Iron ore.....long tons.. | 101,719 | 186,083 | 252,143 | 413,259 |
| Lime.....short tons.. | (a) | (a) | ..... | ..... |
| Manganese ore.....long tons.. | 3,168 | 33,927 | (a) | (a) |
| Manganiferous ore.....do.... | 676 | (a) | (a) | (a) |
| Mica..... | ..... | 635 | ..... | 2,094 |
| Mineral paints, natural pigments.....short tons.. | 11,269 | 111,801 | (c) | (c) |
| Mineral waters.....gallons sold.. | 746,068 | 53,779 | 618,367 | 45,210 |
| Pyrite.....long tons.. | (a) | (a) | (a) | (a) |
| Sand and gravel.....short tons.. | 572,309 | 191,447 | 483,615 | 126,799 |
| Sand-lime brick..... | ..... | (a) | ..... | (a) |
| Silver.....fine ounces (troy).. | 138 | 70 | 74 | 49 |
| Stone..... | ..... | 1,720,313 | ..... | 1,799,210 |
| Talc.....short tons.. | 498 | 12,050 | 3,080 | 88,364 |
| Tripoli..... | ..... | (a) | ..... | ..... |
| Miscellaneous..... | ..... | 569,057 | ..... | 772,135 |
| Total value, eliminating duplications..... | ..... | 5,094,688 | ..... | 6,779,828 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Canvass discontinued.

*Mineral production of Idaho in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons.. | 193 | $29,294 | 259 | $2,946 |
| Asbestos.....do.... | ..... | ..... | (a) | (a) |
| Clay products..... | ..... | (a) | ..... | (a) |
| Clay, raw.....short tons.. | (a b) | (a b) | (a b) | (a b) |
| Coal.....do.... | (a) | (a) | (a) | (a) |
| Copper.....pounds.. | 6,978,713 | 1,221,275 | 8,478,281 | 2,085,657 |
| Gems and precious stones..... | ..... | (a) | ..... | (a) |
| Gold.....fine ounces (troy).. | 57,069 | 1,179,731 | 53,977 | 1,115,810 |
| Iron ore.....long tons.. | (a) | (a) | ..... | ..... |
| Lead.....short tons.. | 173,000 | 16,201,975 | 187,541 | 25,880,643 |
| Lime.....do.... | 3,357 | 19,247 | 4,389 | 31,786 |
| Mica..... | ..... | (a) | ..... | (a) |
| Phosphate rock.....long tons.. | (a) | (a) | ..... | ..... |
| Salt.....short tons.. | (a) | (a) | 44 | 511 |
| Sand and gravel.....do.... | (a) | (a) | (a) | (a) |
| Sand-lime brick..... | ..... | (a) | ..... | (a) |
| Silver.....fine ounces (troy).. | 11,769,128 | 5,966,948 | 12,300,873 | 8,093,974 |
| Stone..... | ..... | 31,228 | ..... | 96,382 |
| Tungsten ore (60 per cent concentrates).....short tons.. | 32 | 47,602 | 101 | 113,470 |
| Zinc.....do.... | 35,077 | 8,699,001 | 43,253 | 11,591,699 |
| Miscellaneous..... | ..... | 156,303 | ..... | 237,460 |
| Total value, eliminating duplications..... | ..... | 33,612,194 | ..... | 49,249,134 |

a Value included under "Miscellaneous." b Value not included in total value.

*Mineral production of Illinois in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asphalt.....short tons.. | 188,575 | $1,041,378 | 155,406 | $1,285,470 |
| Cement.....barrels.. | 5,553,164 | 4,928,679 | [a] 3,562,659 | [a] 3,386,431 |
| Clay products..... | ..... | 14,791,938 | ..... | 17,633,351 |
| Clay, raw.....short tons.. | 163,904 | [b] 169,320 | 197,701 | [b] 378,440 |
| Coal.....do.... | 58,823,576 | 64,622,471 | 66,195,336 | 82,457,954 |
| Coke.....do.... | 1,686,998 | [b] 7,016,635 | 2,320,400 | [b] 10,619,066 |
| Ferroalloys.....long tons.. | [bc] | [bc] | [bc] | [bc] |
| Fluorspar.....short tons.. | [c] | [c] | [c] | [c] |
| Iron, pig.....long tons.. | 2,455,894 | [b] 34,207,901 | 3,857,391 | [b] 67,764,309 |
| Lead.....short tons.. | 954 | 89,676 | 1,072 | 147,936 |
| Lime.....do.... | 88,604 | 352,954 | 80,012 | 369,038 |
| Mineral paints, zinc and lead pigments.....do.... | [c] | [c] | [c] | [c] |
| Mineral waters.....gallons sold.. | 1,559,489 | 75,290 | 1,777,741 | 94,056 |
| Natural gas..... | ..... | 350,371 | ..... | 396,357 |
| Natural-gas gasoline.....gallons.. | 1,035,204 | 80,049 | 2,260,288 | 262,664 |
| Petroleum.....barrels.. | 19,041,695 | 18,655,850 | 17,714,235 | 29,237,168 |
| Pyrite.....long tons.. | 14,849 | 22,476 | 20,482 | 51,432 |
| Sand and gravel.....short tons.. | 7,708,012 | 1,984,569 | 8,335,225 | 2,587,437 |
| Sand and sandstone (finely ground).....do.... | 33,046 | 105,072 | [c] | [c] |
| Sand-lime brick..... | ..... | ..... | ..... | [c] |
| Silver.....fine ounces (troy).. | 3,864 | 1,959 | 5,684 | 3,740 |
| Stone..... | ..... | 2,907,410 | ..... | 3,403,094 |
| Sulphuric acid [d].....short tons.. | ..... | 2,046,311 | ..... | 2,999,548 |
| Tripoli..... | ..... | 59,390 | ..... | 82,968 |
| Zinc.....short tons.. | 5,534 | 1,372,432 | 3,404 | 912,272 |
| Miscellaneous..... | ..... | 2,261,215 | ..... | 5,435,453 |
| Total value, eliminating duplications..... | ..... | 114,446,161 | ..... | 146,780,236 |

[a] Exclusive of natural cement, value for which is included under "Miscellaneous."
[b] Value not included in total value.
[c] Value included under "Miscellaneous."
[d] From zinc smelting.

*Mineral production of Indiana in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Cement.....barrels.. | 8,632,775 | $7,357,951 | [a] 10,350,105 | [a] $11,487,893 |
| Clay products..... | ..... | 7,090,630 | ..... | 9,607,313 |
| Clay, raw.....short tons.. | 52,015 | [b] 45,030 | 69,748 | [b] 65,537 |
| Coal.....do.... | 17,006,152 | 18,637,476 | 20,093,528 | 25,506,246 |
| Coke.....do.... | 2,768,099 | [b] 11,604,588 | 3,489,660 | [b] 16,096,479 |
| Gems and precious stones..... | ..... | ..... | ..... | [c] |
| Iron, pig.....long tons.. | [bc] | [bc] | 1,735,428 | [bc] |
| Lime.....short tons.. | 99,916 | 374,221 | 121,306 | 495,283 |
| Mineral paints, natural pigments.....do.... | [c] | [c] | [d] | [d] |
| Mineral waters.....gallons sold.. | 542,053 | 189,074 | 609,544 | 188,645 |
| Natural gas..... | ..... | 695,380 | ..... | 503,373 |
| Oilstones..... | ..... | [c] | ..... | 25,521 |
| Petroleum.....barrels.. | 875,758 | 813,395 | 769,036 | 1,207,505 |
| Pyrite.....long tons.. | 972 | 3,080 | 772 | 2,445 |
| Sand and gravel.....short tons.. | 5,998,894 | 1,235,071 | 8,165,989 | 1,879,073 |
| Sand-lime brick..... | ..... | 31,702 | ..... | 54,148 |
| Stone..... | ..... | 4,204,192 | ..... | 4,657,813 |
| Sulphuric acid [e].....short tons.. | [c] | [c] | [c] | [c] |
| Miscellaneous..... | ..... | 20,467,054 | ..... | 27,474,536 |
| Total value, eliminating duplications..... | ..... | 41,381,456 | ..... | 56,918,342 |

[a] Exclusive of natural cement, value for which is included under "Miscellaneous."
[b] Value not included in total value.
[c] Value included under "Miscellaneous."
[d] Canvass discontinued.
[e] From zinc smelting.

*Mineral production of Iowa in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Cement.....barrels.. | 4,590,336 | $4,119,952 | 4,853,789 | $6,165,547 |
| Clay products..... | ..... | 6,743,615 | ..... | [a] 7,379,289 |
| Clay, raw.....short tons.. | 11,579 | [b] 5,473 | 21,829 | [b] 2,427 |
| Coal.....do.... | 7,614,143 | 13,577,608 | 7,260,800 | 13,530,383 |
| Ferroalloys.....long tons.. | ..... | ..... | 950 | [b c] |
| Gypsum.....short tons.. | 495,860 | 1,278,128 | 522,293 | 1,496,795 |
| Iron ore.....long tons.. | ..... | ..... | 10,151 | [c] |
| Lead.....short tons.. | ..... | ..... | 14 | 1,932 |
| Lime.....do.... | [c] | [c] | [c] | [c] |
| Mineral paints, natural pigments.....do.... | [c] | [c] | [d] | [d] |
| Mineral waters.....gallons sold.. | 198,739 | 18,534 | 148,732 | 14,404 |
| Natural gas..... | ..... | 250 | ..... | 275 |
| Sand and gravel.....short tons.. | 3,002,806 | 720,795 | 3,321,691 | 980,272 |
| Sand-lime brick..... | ..... | [c] | ..... | ..... |
| Stone..... | ..... | 536,175 | ..... | 561,084 |
| Zinc.....short tons.. | ..... | ..... | 21 | 5,628 |
| Miscellaneous..... | ..... | 53,120 | ..... | 157,325 |
| Total value, eliminating duplications..... | ..... | 27,048,177 | ..... | 30,210,284 |

[a] Exclusive of pottery, value for which is included under "Miscellaneous."
[b] Value not included in total value.
[c] Value included under "Miscellaneous."
[d] Canvass discontinued.

*Mineral production of Kansas in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asphalt.....short tons.. | [a] | [a] | [a] | [a] |
| Cement.....barrels.. | 3,820,735 | $2,842,443 | [b] 4,298,097 | [b] $4,613,609 |
| Clay products..... | ..... | [c] 2,110,877 | ..... | 2,747,803 |
| Coal.....short tons.. | 6,824,474 | 11,360,630 | 6,881,455 | 12,252,723 |
| Gems and precious stones..... | ..... | [a] | ..... | [a] |
| Gypsum.....short tons.. | 60,919 | 250,014 | 78,257 | 322,795 |
| Lead.....do.... | 1,212 | 113,928 | 1,648 | 227,424 |
| Lime.....do.... | ..... | ..... | [a] | [a] |
| Mineral paints, zinc and lead pigments.....do.... | [a] | [a] | [a] | [a] |
| Mineral waters.....gallons sold.. | 155,938 | 63,069 | 237,790 | 58,792 |
| Natural gas..... | ..... | 4,037,011 | ..... | 4,855,389 |
| Natural-gas gasoline.....gallons.. | [a] | [a] | 215,000 | 35,030 |
| Petroleum.....barrels.. | 2,823,487 | 1,702,891 | 8,738,077 | 10,339,958 |
| Pumice.....short tons.. | [a] | [a] | 23,804 | 51,648 |
| Salt.....do.... | 527,123 | 1,035,879 | 639,071 | 1,302,359 |
| Sand and gravel.....do.... | 1,285,496 | 378,355 | 1,164,995 | 303,630 |
| Stone..... | ..... | 537,165 | ..... | 603,490 |
| Sulphuric acid (60° Baumé) [d].....short tons.. | [a] | [a] | [a] | [a] |
| Zinc.....do.... | 14,365 | 3,562,520 | 12,448 | 3,336,064 |
| Miscellaneous..... | ..... | 1,356,192 | ..... | 1,717,111 |
| Total value, eliminating duplications..... | ..... | 29,350,974 | ..... | 42,767,815 |

[a] Value included under "Miscellaneous."
[b] Exclusive of natural cement, value for which is included under "Miscellaneous."
[c] Exclusive of pottery, value for which is included under "Miscellaneous."
[d] From zinc smelting.

*Mineral production of Kentucky in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asphalt.....short tons.. | (a) | (a) | (a) | (a) |
| Barytes.....do.... | 7,753 | $28,427 | 11,068 | $54,995 |
| Cement.....barrels.. | (a) | (a) | (a) | (a) |
| Clay products..... | ..... | 2,441,290 | ..... | 3,559,257 |
| Clay, raw.....short tons.. | 80,684 | b 121,676 | 62,247 | b 170,984 |
| Coal.....do.... | 21,361,674 | 21,494,008 | 25,393,997 | 30,193,047 |
| Coke.....do.... | 526,097 | b 1,129,769 | 802,526 | b 2,225,186 |
| Ferroalloys.....long tons.. | (a b) | (a b) | 40,431 | (a b) |
| Fluorspar.....short tons.. | 19,219 | 129,873 | (a) | (a) |
| Iron, pig.....long tons.. | 105,700 | b 1,420,275 | 144,444 | b 2,595,600 |
| Lead.....short tons.. | 251 | 23,594 | 153 | 21,114 |
| Lime.....do.... | 1,307 | 7,070 | 1,236 | 6,304 |
| Lithographic stone.....do.... | ..... | ..... | 20 | 1,500 |
| Mineral waters.....gallons sold.. | 459,841 | 63,278 | 377,246 | 52,305 |
| Natural gas..... | ..... | 614,998 | ..... | 752,635 |
| Natural-gas gasoline.....gallons.. | (a) | (a) | 725,467 | 141,347 |
| Oilstones..... | ..... | (a) | ..... | (a) |
| Petroleum.....barrels.. | 437,274 | 418,357 | 1,202,569 | 2,188,295 |
| Phosphate rock.....long tons.. | ..... | ..... | (a) | (a) |
| Sand and gravel.....short tons.. | 944,713 | 397,764 | 1,053,431 | 474,216 |
| Sand-lime brick..... | ..... | (a) | ..... | (a) |
| Stone..... | ..... | 1,071,052 | ..... | 1,403,110 |
| Zinc.....short tons.. | 764 | 189,472 | 1,096 | 293,728 |
| Miscellaneous..... | ..... | 717,502 | ..... | 1,668,158 |
| Total value, eliminating duplications..... | ..... | 27,278,627 | ..... | 39,989,007 |

a Value included under "Miscellaneous." b Value not included in total value.

*Mineral production of Louisiana in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asphalt.....short tons.. | (a) | (a) | ..... | ..... |
| Clay products..... | ..... | b $385,002 | ..... | b $360,855 |
| Clay, raw.....short tons.. | (a c) | (a c) | ..... | ..... |
| Mineral waters.....gallons sold.. | 513,838 | 30,771 | 429,650 | 31,068 |
| Natural gas..... | ..... | 2,163,934 | ..... | 2,660,445 |
| Natural-gas gasoline.....gallons.. | (a) | (a) | 2,113,159 | 269,564 |
| Petroleum.....barrels.. | 18,191,539 | 10,804,653 | 15,248,138 | 14,669,774 |
| Potash ($K_2O$).....short tons.. | ..... | ..... | (a) | (a) |
| Salt.....do.... | (a) | (a) | (a) | (a) |
| Sand and gravel.....do.... | (a) | (a) | 1,579,701 | 535,968 |
| Stone..... | ..... | (a) | ..... | (a) |
| Sulphur.....long tons.. | (a) | (a) | (a) | (a) |
| Miscellaneous..... | ..... | 4,831,582 | ..... | 9,492,869 |
| Total value, eliminating duplications..... | ..... | 18,215,847 | ..... | 28,020,543 |

a Value included under "Miscellaneous."
b Exclusive of pottery, value for which is included under "Miscellaneous."
c Value not included in total value.

*Mineral production of Maine in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products..... | ..... | a $488,079 | ..... | a $546,725 |
| Feldspar.....short tons.. | 27,878 | 191,456 | 28,006 | 235,922 |
| Gems and precious stones..... | ..... | 2,856 | ..... | 8,458 |
| Lime.....short tons.. | 146,400 | 945,108 | 162,100 | 956,371 |
| Mineral waters.....gallons sold.. | 1,115,648 | 338,003 | 1,038,861 | 353,792 |
| Potash ($K_2O$).....short tons.. | ..... | ..... | (b) | (b) |
| Sand and gravel.....do.... | (b) | (b) | (b) | (b) |
| Silica (quartz).....do.... | (b) | (b) | ..... | ..... |
| Slate..... | ..... | (b) | ..... | (b) |
| Stone..... | ..... | 1,062,283 | ..... | 1,068,485 |
| Miscellaneous..... | ..... | 274,122 | ..... | 369,328 |
| Total value, eliminating duplications..... | ..... | 3,301,907 | ..... | 3,539,061 |

a Exclusive of pottery, value for which is included under "Miscellaneous."
b Value included under "Miscellaneous."

*Mineral production of Maryland in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Briquets, fuel.....short tons.. | (a b) | (a b) | (a b) | (a b) |
| Cement.....barrels.. | (a) | (a) | (a) | (a) |
| Chromic iron ore.....long tons.. | | | (a) | (a) |
| Clay products..... | | $1,576,456 | | $1,825,870 |
| Clay, raw.....short tons.. | 17,157 | b 32,966 | 45,975 | b 82,667 |
| Coal.....do.... | 4,180,477 | 5,330,845 | 4,460,046 | 6,947,623 |
| Coke.....do.... | 313,283 | b 762,664 | 489,982 | b 1,387,009 |
| Copper.....pounds.. | | | 158,780 | 39,060 |
| Diatomaceous earth..... | | (a) | | (a) |
| Feldspar.....short tons.. | 12,485 | 36,861 | 23,928 | 83,957 |
| Ferroalloys.....long tons.. | (a b) | (a b) | (a b) | (a b) |
| Iron ore.....do.... | 1,500 | 2,750 | (a) | (a) |
| Iron, pig.....do.... | (a b) | (a b) | 465,865 | (a b) |
| Lime.....short tons.. | 130,597 | 409,588 | 157,673 | 574,998 |
| Mineral paints, natural pigments.....do.... | (a) | (a) | (c) | (c) |
| Mineral waters.....gallons sold.. | 1,433,406 | 105,581 | 1,312,788 | 99,020 |
| Potash ($K_2O$).....short tons.. | | | (a) | (a) |
| Sand and gravel.....do.... | 1,683,427 | 579,555 | 1,872,159 | 900,061 |
| Sand and sandstone (finely ground).....do.... | (a) | (a) | | |
| Silica (quartz).....do.... | 6,207 | 36,857 | 7,203 | 31,712 |
| Silver.....fine ounces (troy).. | | | 575 | 378 |
| Slate..... | | 91,277 | | 71,737 |
| Stone..... | | 916,525 | | 921,909 |
| Talc and soapstone.....short tons.. | (a) | (a) | (a) | (a) |
| Miscellaneous..... | | 5,841,164 | | 15,519,309 |
| Total value, eliminating duplications..... | | 10,581,224 | | 13,335,013 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Canvass discontinued.

*Mineral production of Massachusetts in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products..... | | $1,583,604 | | $1,892,558 |
| Clay, raw.....short tons.. | 699 | a 1,313 | 892 | a 1,296 |
| Coke.....do.... | 504,438 | (a b) | 563,048 | (a b) |
| Diatomaceous earth..... | | (b) | | (b) |
| Fuller's earth.....short tons.. | (b) | (b) | (b) | (b) |
| Gems and precious stones..... | | (b) | | (b) |
| Iron ore.....long tons.. | 3,950 | (b) | (b) | (b) |
| Iron, pig.....do.... | (a b) | (a b) | (a b) | (a b) |
| Lime.....short tons.. | 135,580 | 669,629 | 145,020 | 811,402 |
| Mineral waters.....gallons sold.. | 3,872,192 | 184,133 | 3,124,096 | 128,478 |
| Potash ($K_2O$).....short tons.. | | | (b) | (b) |
| Sand and gravel.....do.... | 747,747 | 387,371 | 1,049,577 | 533,308 |
| Sand-lime brick..... | | 101,250 | | 110,333 |
| Silica (quartz).....short tons.. | (b) | (b) | (b) | (b) |
| Stone..... | | 3,326,057 | | 3,138,165 |
| Talc.....short tons.. | (b) | (b) | (b) | (b) |
| Miscellaneous..... | | 1,723,691 | | 2,345,780 |
| Total value, eliminating duplications..... | | 6,286,860 | | 6,683,844 |

a Value not included in total value.
b Value included under "Miscellaneous."

*Mineral production of Michigan in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Briquets, fuel.....short tons.. | (a b) | (a b) | (a b) | (a b) |
| Bromine.....pounds.. | (a) | (a) | (a) | (a) |
| Calcium chloride.....short tons.. | (a) | (a) | (a) | (a) |
| Cement.....barrels.. | 4,727,768 | $4,454,608 | 5,151,818 | $6,017,911 |
| Clay products..... | ..... | 2,770,057 | ..... | 3,497,770 |
| Clay, raw.....short tons.. | 3,142 | b 5,605 | 3,454 | b 11,153 |
| Coal.....do.... | 1,156,138 | 2,372,797 | 1,180,360 | 2,653,182 |
| Coke.....do.... | (a b) | (a b) | (a b) | (a b) |
| Copper.....pounds.. | 265,283,378 | 46,424,591 | 273,692,525 | 67,328,361 |
| Gems and precious stones..... | ..... | 550 | ..... | 113 |
| Graphite, amorphous.....short tons.. | ..... | ..... | (a) | (a) |
| Grindstones..... | ..... | (a) | ..... | (a) |
| Gypsum.....short tons.. | 389,791 | 686,309 | 457,375 | 1,066,599 |
| Iron ore.....long tons.. | 13,664,437 | 28,218,627 | 18,995,797 | 49,054,340 |
| Iron, pig.....do.... | 486,106 | b 6,624,559 | 505,646 | b 8,851,361 |
| Lime.....short tons.. | 81,359 | 349,979 | 86,447 | 385,341 |
| Mineral paints, natural pigments.....do.... | (a) | (a) | c 2,641 | (a) |
| Mineral waters.....gallons sold.. | 913,765 | 72,711 | 996,875 | 108,867 |
| Natural gas..... | ..... | 1,510 | ..... | 948 |
| Petroleum.....barrels.. | (a) | (a) | (a) | (a) |
| Potash ($K_2O$).....short tons.. | ..... | ..... | 314 | 207,175 |
| Salt.....do.... | 1,762,430 | 4,304,731 | 2,088,559 | 4,612,567 |
| Sand and gravel.....do.... | 3,776,726 | 1,036,739 | 4,407,475 | 1,306,256 |
| Sand-lime brick..... | ..... | 286,948 | ..... | 499,711 |
| Scythestones..... | ..... | (a) | ..... | (a) |
| Silica (quartz).....short tons.. | (a) | (a) | (a) | (a) |
| Silver.....fine ounces (troy).. | 585,933 | 297,068 | 716,640 | 471,549 |
| Stone..... | ..... | 1,943,668 | ..... | 2,494,284 |
| Miscellaneous..... | ..... | 3,387,707 | ..... | 4,052,304 |
| Total value, eliminating duplications..... | ..... | 93,938,255 | ..... | 140,666,124 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Iron ore sold for paint. General canvass of mineral paint industry discontinued.

*Mineral production of Minnesota in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Cement.....barrels.. | (a) | (a) | 868,300 | $911,705 |
| Clay products..... | ..... | b $1,645,913 | ..... | b 2,064,362 |
| Clay, raw.....short tons.. | (a c) | (a c) | (a c) | (a c) |
| Coke.....do.... | 127,847 | c 475,952 | 431,319 | c 1,968,675 |
| Gems and precious stones..... | ..... | (a) | ..... | (a) |
| Iron ore.....long tons.. | 32,545,236 | 57,742,643 | 45,869,251 | 106,628,784 |
| Iron, pig.....do.... | (a c) | (a c) | 377,132 | (a c) |
| Lime.....short tons.. | 20,359 | 96,190 | 20,150 | 103,000 |
| Manganiferous ore.....long tons.. | 42,973 | 187,971 | 240,403 | 790,762 |
| Mineral waters.....gallons sold.. | 3,493,887 | 136,259 | 4,188,434 | 145,582 |
| Sand and gravel.....short tons.. | 1,508,890 | 327,975 | 1,468,530 | 491,270 |
| Sand-lime brick..... | ..... | 151,128 | ..... | 178,828 |
| Stone..... | ..... | 1,492,341 | ..... | 1,833,800 |
| Miscellaneous..... | ..... | 1,849,770 | ..... | 6,210,674 |
| Total value, eliminating duplications..... | ..... | 62,391,440 | ..... | 113,662,522 |

a Value included under "Miscellaneous."
b Exclusive of pottery, value for which is included under "Miscellaneous."
c Value not included in total value.

*Mineral production of Mississippi in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products | | $367,619 | | $520,618 |
| Clay, raw, short tons | (a b) | (a b) | (a b) | (a b) |
| Mineral waters, gallons sold | 259,370 | 45,639 | 399,248 | 48,439 |
| Sand and gravel, short tons | 1,299,813 | 252,885 | 1,435,460 | 321,509 |
| Miscellaneous | | 1,100 | | 100 |
| Total value, eliminating duplications | | 666,143 | | 890,566 |

a Value included under "Miscellaneous."
b Value not included in total value.

*Mineral production of Missouri in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Barytes, short tons | 39,113 | $158,597 | 58,223 | $365,111 |
| Briquets, fuel, do | (a b) | (a b) | (a b) | (a b) |
| Cement, do | 4,628,484 | 4,007,679 | 5,732,001 | 6,333,567 |
| Chats, do | 2,309,191 | 346,379 | 2,890,970 | 433,646 |
| Clay products | | 5,431,569 | | 7,640,995 |
| Clay, raw, short tons | 308,385 | b 641,040 | 439,583 | b 988,884 |
| Coal, do | 3,811,593 | 6,595,918 | 4,742,146 | 9,044,505 |
| Coke, do | (a b) | (a b) | (a b) | (a b) |
| Copper, pounds | 402,160 | 70,378 | 386,200 | 95,005 |
| Gems and precious stones | | | | (a) |
| Iron ore, long tons | 40,290 | 99,853 | 34,914 | 116,484 |
| Iron, pig, do | (a b) | (a b) | 39,018 | (a b) |
| Lead, short tons | 210,440 | 19,781,360 | 233,088 | 32,166,144 |
| Lime, do | 155,501 | 691,042 | 199,260 | 956,300 |
| Mineral paints: | | | | |
| Natural pigments, do | (a) | (a) | (c) | (c) |
| Zinc and lead pigments, do | (a) | (a) | (a) | (a) |
| Mineral waters, gallons sold | 1,000,961 | 83,363 | 1,394,092 | 109,814 |
| Natural gas | | 7,731 | | 17,594 |
| Petroleum, barrels | (a) | (a) | (a) | (a) |
| Potash ($K_2O$), short tons | | | (a) | (a) |
| Pyrite, long tons | (a) | (a) | (a) | (a) |
| Sand and gravel, short tons | 2,889,211 | 675,484 | 3,643,205 | 877,634 |
| Silver, fine ounces (troy) | 57,756 | 29,282 | 129,450 | 85,178 |
| Stone | | 2,145,501 | | 2,242,742 |
| Tripoli | | 68,451 | | d 92,248 |
| Tungsten ore (60 per cent concentrates), short tons | | | 5 | 2,657 |
| Zinc, do | 136,300 | 33,802,400 | 155,960 | 41,797,280 |
| Miscellaneous | | 1,937,354 | | 3,141,535 |
| Total value, eliminating duplications | | 74,953,623 | | 103,526,424 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Canvass discontinued.
d Includes small product from Oklahoma. Not separable.

*Mineral production of Montana in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Cement.....barrels | (a) | (a) | (a) | (a) |
| Clay products | ..... | [b] $524,575 | ..... | [b] $717,551 |
| Clay, raw.....short tons | 3,670 | [c] 17,842 | (a c) | (a c) |
| Coal.....do | 2,789,755 | 4,526,509 | 3,632,527 | 6,286,197 |
| Copper.....pounds | 267,231,014 | 46,765,427 | 352,928,373 | 86,820,380 |
| Gems and precious stones | ..... | 105,355 | ..... | 108,263 |
| Gold.....fine ounces (troy) | 242,078 | 5,004,195 | 220,130 | 4,550,494 |
| Graphite, crystalline.....pounds | (a) | (a) | (a) | (a) |
| Gypsum.....short tons | (a) | (a) | (a) | (a) |
| Lead.....do | 6,878 | 646,549 | 6,798 | 938,064 |
| Lime.....do | (a) | (a) | (a) | (a) |
| Manganese ore.....long tons | ..... | ..... | 3,268 | 25,378 |
| Manganiferous ore.....do | ..... | ..... | (a) | (a) |
| Mineral waters.....gallons sold | 114,245 | 6,603 | 181,800 | 12,294 |
| Natural gas | ..... | 2,500 | ..... | 38,855 |
| Petroleum.....barrels | ..... | ..... | 44,917 | 44,019 |
| Sand and gravel.....short tons | 16,387 | 13,205 | 296,737 | 58,185 |
| Silver.....fine ounces (troy) | 14,378,437 | 7,289,868 | 16,494,366 | 10,853,293 |
| Stone | ..... | 263,812 | ..... | 261,460 |
| Sulphuric acid (60° Baume) [d].....short tons | ..... | ..... | (a) | (a) |
| Tungsten ore (60 per cent concentrates).....do | ..... | ..... | 1 | 1,163 |
| Zinc.....do | 93,573 | 23,206,215 | 114,630 | 30,720,716 |
| Miscellaneous | ..... | 792,325 | ..... | 1,233,980 |
| Total value, eliminating duplications | ..... | 89,147,138 | ..... | 142,650,179 |

[a] Value included under "Miscellaneous."
[b] Exclusive of pottery, value for which is included under "Miscellaneous."
[c] Value not included in total value.
[d] From copper smelting.

*Mineral production of Nebraska in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Cement.....barrels | (a) | (a) | ..... | ..... |
| Clay products | ..... | [b] $776,899 | ..... | [b] $943,553 |
| Clay, raw.....short tons | (a c) | (a c) | (a c) | (a c) |
| Mineral waters.....gallons sold | 8,770 | 962 | 8,440 | 946 |
| Potash ($K_2O$).....short tons | ..... | ..... | (a) | (a) |
| Pumice.....do | (a) | (a) | 9,259 | 25,155 |
| Sand and gravel.....do | 1,075,139 | 200,920 | 1,267,998 | 289,872 |
| Sand-lime brick | ..... | (a) | ..... | ..... |
| Stone | ..... | 321,341 | ..... | 406,707 |
| Miscellaneous | ..... | 214,654 | ..... | 1,772,522 |
| Total value, eliminating duplications | ..... | 1,514,171 | ..... | 3,436,774 |

[a] Value included under "Miscellaneous."
[b] Exclusive of pottery, value for which is included under "Miscellaneous."
[c] Value not included in total value.

*Mineral production of Nevada in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons.. | 1,500 | $110,000 | 1,400 | $13,216 |
| Barytes.....do.... | ..... | ..... | (a) | (a) |
| Clay products..... | ..... | (a) | ..... | (a) |
| Coal.....short tons.. | (a) | (a) | ..... | ..... |
| Copper.....pounds.. | 68,636,370 | 12,011,365 | 105,116,813 | 25,858,736 |
| Diatomaceous earth..... | ..... | (a) | ..... | (a) |
| Gems and precious stones..... | ..... | 6,333 | ..... | 15,734 |
| Gold.....fine ounces (troy).. | 551,683 | 11,404,300 | 428,904 | 8,866,287 |
| Graphite, amorphous.....short tons.. | (a) | (a) | (a) | (a) |
| Gypsum.....do.... | (a) | (a) | (a) | (a) |
| Iron ore.....long tons.. | 3,993 | (a) | 9,910 | (a) |
| Lead.....short tons.. | 8,319 | 781,952 | 12,819 | 1,768,972 |
| Lime.....do.... | (a) | (a) | (a) | (a) |
| Manganese ore.....long tons.. | ..... | ..... | (a) | (a) |
| Manganiferous ore.....do.... | 104,498 | (a) | 122,429 | (a) |
| Mineral waters.....gallons sold.. | 303,150 | 4,294 | 346,260 | 4,160 |
| Molybdenum.....pounds.. | (a) | (a) | ..... | ..... |
| Pebbles for grinding.....short tons.. | ..... | ..... | (a) | (a) |
| Platinum and allied metals.....fine ounces (troy).. | ..... | ..... | (a) | (a) |
| Quicksilver.....flasks.. | 2,327 | 199,657 | 2,198 | 276,706 |
| Salt.....short tons.. | 970 | 3,950 | (a) | (a) |
| Sand and gravel.....do.... | 17,491 | 1,775 | (a) | (a) |
| Silver.....fine ounces (troy).. | 14,459,840 | 7,331,139 | 13,837,525 | 9,105,092 |
| Sulphur.....long tons.. | (a) | (a) | (a) | (a) |
| Tungsten ore (60 per cent concentrates)....short tons.. | 55 | 130,466 | 689 | 2,240,619 |
| Zinc.....do.... | 12,188 | 3,022,680 | 16,222 | 4,347,387 |
| Miscellaneous..... | ..... | 983,980 | ..... | 1,013,700 |
| Total value, eliminating duplications..... | ..... | 35,991,891 | ..... | 53,510,559 |

a Value included under "Miscellaneous."

*Mineral production of New Hampshire in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products..... | ..... | a $484,464 | ..... | a $473,434 |
| Diatomaceous earth..... | ..... | (b) | ..... | (b) |
| Feldspar.....short tons.. | (b) | (b) | (b) | (b) |
| Fluorspar.....do.... | (b) | (b) | (b) | (b) |
| Garnet.....do.... | (b) | (b) | (b) | (b) |
| Gems and precious stones..... | ..... | 200 | ..... | 550 |
| Lead.....short tons.. | (b) | (b) | 47 | 6,433 |
| Mica..... | ..... | 66,971 | ..... | 75,239 |
| Mineral waters.....gallons sold.. | 176,385 | 6,737 | 269,860 | 14,935 |
| Sand and gravel.....short tons.. | 583,200 | 77,760 | (b) | (b) |
| Scythestones..... | ..... | (b) | ..... | (b) |
| Silver.....fine ounces (troy).. | 26 | 13 | 945 | 622 |
| Stone..... | ..... | 1,234,149 | ..... | 1,141,810 |
| Zinc.....short tons.. | (b) | (b) | 36 | 9,681 |
| Miscellaneous..... | ..... | 37,655 | ..... | 95,019 |
| Total value, eliminating duplications..... | ..... | 1,907,949 | ..... | 1,817,723 |

a Exclusive of pottery, value for which is included under "Miscellaneous."
b Value included under "Miscellaneous."

*Mineral production of New Jersey in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Briquets, fuel.....short tons.. | ..... | ..... | (a b) | (a b) |
| Cement.....barrels.. | 1,977,474 | $1,473,499 | 2,592,302 | $2,534,623 |
| Clay products..... | ..... | 15,965,418 | ..... | 20,814,402 |
| Clay, raw.....short tons.. | 340,726 | b 617,904 | 371,916 | b 790,796 |
| Coke.....do.... | (a b) | (a b) | (a b) | (a b) |
| Iron ore.....long tons.. | 391,115 | 1,140,400 | 528,084 | 1,877,056 |
| Iron, pig.....do.... | (a b) | (a b) | 75,433 | (a b) |
| Lime.....short tons.. | 10,273 | 35,393 | 7,110 | 26,084 |
| Manganiferous zinc residuume.....long tons.. | 159,318 | (a) | 198,817 | (a) |
| Marl, greensand.....short tons.. | 866 | 433 | 1,220 | 610 |
| Mineral waters.....gallons sold.. | 1,479,479 | 116,226 | 1,580,028 | 130,998 |
| Potash ($K_2O$).....short tons.. | ..... | ..... | (a) | (a) |
| Sand and gravel.....do.... | 4,968,104 | 1,447,557 | 3,936,020 | 1,517,473 |
| Sand-lime brick..... | ..... | (a) | ..... | (a) |
| Slate..... | ..... | 6,551 | ..... | (a) |
| Stone..... | ..... | 1,601,044 | ..... | 1,655,602 |
| Talc.....short tons.. | (a) | (a) | (a) | (a) |
| Zinc.....do.... | 116,618 | (a) | 110,698 | (a) |
| Miscellaneous..... | ..... | 18,844,554 | ..... | 34,658,439 |
| Total value, eliminating duplications..... | ..... | 38,818,422 | ..... | 61,114,525 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Ore mined in New Jersey: smelted in Pennsylvania.

*Mineral production of New Mexico in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products..... | ..... | $240,847 | ..... | $257,561 |
| Clay, raw.....short tons.. | 2,568 | a 7,320 | 3,602 | a 9,511 |
| Coal.....do.... | 3,817,940 | 5,481,361 | 3,793,011 | 5,580,369 |
| Coke.....do.... | 389,411 | a 1,265,268 | 502,812 | a 1,718,976 |
| Copper.....pounds.. | 76,788,366 | 13,437,964 | 92,747,289 | 22,815,833 |
| Fluorspar.....short tons.. | (b) | (b) | ..... | ..... |
| Gems and precious stones..... | ..... | (b) | ..... | 675 |
| Gold.....fine ounces (troy).. | 70,681 | 1,461,105 | 66,877 | 1,382,480 |
| Gypsum.....short tons.. | (b) | (b) | (b) | (b) |
| Iron ore.....long tons.. | 34,806 | 54,197 | 157,779 | 168,157 |
| Lead.....short tons.. | 2,271 | 213,491 | 4,107 | 566,779 |
| Lime.....do.... | 1,720 | 11,963 | 1,582 | 11,670 |
| Manganiferous ore.....long tons.. | ..... | ..... | 16,574 | 47,966 |
| Mineral waters.....gallons sold.. | 42,400 | 6,680 | 35,450 | 5,965 |
| Salt.....short tons.. | (b) | (b) | (b) | (b) |
| Sand and gravel.....do.... | (b) | (b) | (b) | (b) |
| Silver.....fine ounces (troy).. | 2,005,531 | 1,016,804 | 1,766,274 | 1,162,208 |
| Stone..... | ..... | 308,809 | ..... | 77,290 |
| Tungsten ore (60 per cent concentrates).....short tons.. | 45 | 70,934 | 16 | 39,227 |
| Zinc.....do.... | 12,702 | 3,150,104 | 18,285 | 4,900,467 |
| Miscellaneous..... | ..... | 94,902 | ..... | 108,854 |
| Total value, eliminating duplications..... | ..... | 25,549,161 | ..... | 37,123,501 |

a Value not included in total value.
b Value included under "Miscellaneous."

*Mineral production of New York in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Abrasives, artificial.....pounds.. | (a b) | (a b) | (a b) | (a b) |
| Aluminum.....do.... | (a b) | (a b) | (a b) | (a b) |
| Cement.....barrels.. | 5,504,365 | $4,153,802 | c 5,603,477 | c $5,752,809 |
| Clay products..... | ..... | 9,489,002 | ..... | 11,755,012 |
| Clay, raw.....short tons.. | 7,261 | b 15,913 | 11,158 | b 36,413 |
| Coke.....do.... | 684,461 | b 2,459,463 | 775,014 | b 3,033,276 |
| Diatomaceous earth..... | ..... | (a) | ..... | (a) |
| Emery.....short tons.. | 3,063 | 31,131 | 15,282 | 123,901 |
| Feldspar.....do.... | 17,375 | 65,988 | 17,426 | 82,461 |
| Ferroalloys.....long tons.. | ..... | ..... | (a b) | (a b) |
| Garnet, abrasive.....short tons.. | 3,951 | 136,514 | 5,840 | 198,200 |
| Gems and precious stones..... | ..... | (a) | ..... | (a) |
| Graphite: | | | | |
| Artificial.....pounds.. | 5,084,000 | b 99,633 | 8,397,281 | (a b) |
| Crystalline.....do.... | (a) | (a) | (a) | (a) |
| Gypsum.....short tons.. | 540,914 | 1,267,706 | 579,827 | 1,459,587 |
| Iron ore.....long tons.. | 931,745 | 2,797,270 | 1,464,917 | 5,571,429 |
| Iron, pig.....do.... | 2,010,076 | b 28,178,466 | 2,289,608 | b 40,537,240 |
| Lime.....short tons.. | 115,861 | 575,384 | 117,490 | 636,668 |
| Marl, calcareous.....do.... | ..... | ..... | (a) | (a) |
| Mica..... | ..... | (a) | ..... | (a) |
| Millstones..... | ..... | 16,883 | ..... | 10,287 |
| Mineral paints, natural pigments.....short tons.. | 13,354 | 112,108 | d 14,572 | d 34,296 |
| Mineral waters.....gallons sold.. | 8,411,616 | 711,697 | 7,746,490 | 697,650 |
| Natural gas..... | ..... | 2,335,252 | ..... | 2,524,115 |
| Natural-gas gasoline.....gallons.. | (a) | (a) | (a) | (a) |
| Petroleum.....barrels.. | 887,778 | 1,390,325 | 874,087 | 2,190,195 |
| Potash ($K_2O$).....short tons.. | ..... | ..... | (a) | (a) |
| Pyrite.....long tons.. | (a) | (a) | (a) | (a) |
| Salt.....short tons.. | 1,570,446 | 2,976,405 | 1,972,285 | 3,698,798 |
| Sand and gravel.....do.... | 7,449,807 | 2,416,522 | 8,098,097 | 2,644,829 |
| Sand-lime brick..... | ..... | 121,114 | ..... | c 109,037 |
| Silica (quartz).....short tons.. | (a) | (a) | (a) | (a) |
| Slate..... | ..... | 127,603 | ..... | 21,345 |
| Stone..... | ..... | 5,731,849 | ..... | 5,342,954 |
| Talc, fibrous.....short tons.. | 88,214 | 864,843 | 93,236 | 961,510 |
| Zinc.....do.... | (a) | (a) | 4,507 | 1,207,973 |
| Miscellaneous..... | ..... | 17,464,138 | ..... | 31,334,639 |
| Total value, eliminating duplications..... | ..... | 36,414,038 | ..... | 45,783,230 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of natural cement, value for which is included under "Miscellaneous."
d Crude iron ore sold for paint. General canvass of mineral paint industry discontinued.
e Exclusive of fancy brick, value for which is included under "Miscellaneous."

*Mineral production of North Carolina in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Aluminum.....pounds.. | ..... | ..... | (a b) | (a b) |
| Barytes.....short tons.. | (a) | (a) | 878 | $3,246 |
| Clay products..... | ..... | $1,089,935 | ..... | 1,551,436 |
| Clay, raw.....short tons.. | 16,069 | b 143,696 | 17,562 | b 151,823 |
| Copper.....pounds.. | 17,170 | 3,005 | 9,800 | 2,411 |
| Feldspar.....short tons.. | (a) | (a) | 34,670 | 77,446 |
| Garnet, abrasive.....do.... | ..... | ..... | (a) | (a) |
| Gems and precious stones..... | ..... | 464 | ..... | 343 |
| Gold.....fine ounces (troy).. | 8,321 | 172,001 | 1,269 | 26,237 |
| Graphite, amorphous.....short tons.. | ..... | ..... | (a) | (a) |
| Iron ore.....long tons.. | 66,453 | (a) | 64,306 | (a) |
| Lime.....short tons.. | (a) | (a) | (a) | (a) |
| Mica..... | ..... | 300,593 | ..... | 422,580 |
| Millstones..... | ..... | (a) | ..... | (a) |
| Mineral waters.....gallons sold.. | 132,813 | 18,745 | 137,817 | 19,010 |
| Monazite sand.....pounds.. | 36,000 | 3,600 | (a) | (a) |
| Sand and gravel.....short tons.. | 424,740 | 124,697 | 554,381 | 150,209 |
| Silica (quartz).....do.... | (a) | (a) | (a) | (a) |
| Silver.....fine ounces (troy).. | 1,465 | 743 | 663 | 436 |
| Stone..... | ..... | 1,409,963 | ..... | 1,987,876 |
| Talc.....short tons.. | 1,454 | 21,501 | 1,787 | 41,824 |
| Tin (metallic equivalent).....do.... | ..... | ..... | (a) | (a) |
| Miscellaneous..... | ..... | 220,558 | ..... | 854,897 |
| Total value, eliminating duplications..... | ..... | 3,365,805 | ..... | 4,595,551 |

a Value included under "Miscellaneous." b Value not included in total value.

*Mineral production of North Dakota in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Briquets, fuel.....short tons.. | (a b) | (a b) | ..... | ..... |
| Clay products..... | ..... | $183,355 | ..... | $264,457 |
| Clay, raw.....short tons.. | (a b) | (a b) | (a b) | (a b) |
| Coal.....do.... | 528,078 | 766,072 | 634,912 | 946,082 |
| Mineral waters.....gallons sold.. | 475,000 | 8,750 | 766,000 | 14,500 |
| Natural gas..... | ..... | (a) | ..... | (a) |
| Sand and gravel.....short tons.. | 30,240 | 12,135 | (a) | (a) |
| Sand-lime brick..... | ..... | (a) | ..... | (a) |
| Miscellaneous..... | ..... | 16,957 | ..... | 59,283 |
| Total value, eliminating duplications..... | ..... | 985,885 | ..... | 1,283,809 |

a Value included under "Miscellaneous."
b Value not included in total value.

*Mineral production of Ohio in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Bromine.....pounds.. | 125,135 | $165,648 | 78,773 | $87,361 |
| Calcium chloride.....short tons.. | 5,418 | 30,406 | (a) | (a) |
| Cement.....barrels.. | 1,983,217 | 1,940,524 | b 2,142,931 | b 2,517,949 |
| Clay products..... | ..... | 36,839,021 | ..... | 44,947,877 |
| Clay, raw.....short tons.. | 285,590 | c 247,413 | 324,722 | c 309,369 |
| Coal.....do.... | 22,434,691 | 24,207,075 | 34,728,219 | 46,150,907 |
| Coke.....do.... | 684,658 | c 2,136,433 | 1,803,268 | c 6,894,619 |
| Ferroalloys.....long tons.. | 82,637 | c 1,414,971 | 91,032 | c 2,179,338 |
| Grindstones and pulpstones..... | ..... | 571,113 | ..... | 637,919 |
| Gypsum.....short tons.. | 259,036 | 772,520 | 286,678 | 927,859 |
| Iron ore.....long tons.. | 3,502 | 8,535 | 1,800 | (a) |
| Iron, pig.....do.... | 6,995,000 | c90,549,626 | 8,689,030 | c136,855,228 |
| Lime.....short tons.. | 507,993 | 1,954,813 | 570,972 | 2,702,953 |
| Mineral waters.....gallons sold.. | 3,504,343 | 133,416 | 4,102,922 | 161,160 |
| Natural gas..... | ..... | 17,391,060 | ..... | 15,601,144 |
| Natural-gas gasoline.....gallons.. | 2,198,715 | 167,138 | 2,638,571 | 470,804 |
| Oilstones and scythestones..... | ..... | (a) | ..... | (a) |
| Petroleum.....barrels.. | 7,825,326 | 10,061,493 | 7,744,511 | 16,154,940 |
| Potash ($K_2O$).....short tons.. | ..... | ..... | (a) | (a) |
| Pyrite.....long tons.. | 10,857 | 27,404 | 13,551 | 36,114 |
| Salt.....short tons.. | 823,234 | 1,462,192 | 938,867 | 2,038,749 |
| Sand and gravel.....do.... | 6,861,023 | 2,634,145 | 8,350,250 | 3,559,952 |
| Sand and sandstone (finely ground).....do.... | ..... | ..... | (a) | (a) |
| Sand-lime brick..... | ..... | (a) | ..... | (a) |
| Stone..... | ..... | 5,816,923 | ..... | 6,611,266 |
| Sulphuric acid d.....short tons.. | (a) | (a) | (a) | (a) |
| Miscellaneous..... | ..... | 1,013,763 | ..... | 2,473,263 |
| Total value, eliminating duplications..... | ..... | 105,198,086 | ..... | 145,080,217 |

a Value included under "Miscellaneous."
b Exclusive of natural cement, value for which is included under "Miscellaneous."
c Value not included in total value.
d From zinc smelting.

*Mineral production of Oklahoma in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asphalt: | | | | |
| Natural.....short tons.. | 16,907 | $118,351 | 15,431 | $112,555 |
| Oil.....do.... | (a) | (a) | (a) | (a) |
| Cement.....barrels.. | (a) | (a) | (a) | (a) |
| Clay products..... | ..... | 996,451 | ..... | 1,410,657 |
| Coal.....short tons.. | 3,693,580 | 7,435,906 | 3,608,011 | 7,525,427 |
| Gems and precious stones..... | ..... | ..... | ..... | (a) |
| Gypsum.....short tons.. | 110,790 | 294,230 | 161,661 | 429,350 |
| Lead.....do.... | 7,306 | 686,764 | 12,115 | 1,671,870 |
| Lime.....do.... | (a) | (a) | (a) | (a) |
| Mineral paints, zinc and lead pigments.....do.... | ..... | ..... | (a) | (a) |
| Mineral waters.....gallons sold.. | 890,392 | 24,005 | 1,353,513 | 40,189 |
| Natural gas..... | ..... | 9,195,804 | ..... | 11,983,774 |
| Natural-gas gasoline.....gallons.. | 31,665,991 | 2,361,029 | 48,359,602 | 5,865,145 |
| Petroleum.....barrels.. | 97,915,243 | 56,706,133 | 107,071,715 | 128,463,805 |
| Salt.....short tons.. | (a) | (a) | (a) | (a) |
| Sand and gravel.....do.... | (a) | (a) | 574,844 | 196,206 |
| Silver.....fine ounces (troy).. | ..... | ..... | 606 | 399 |
| Stone..... | ..... | 430,302 | ..... | 621,056 |
| Tripoli..... | ..... | ..... | ..... | (b) |
| Zinc.....short tons.. | 14,314 | 3,549,872 | 28,754 | 7,706,272 |
| Miscellaneous..... | ..... | 1,874,144 | ..... | 3,560,047 |
| Total value, eliminating duplications..... | ..... | 83,672,991 | ..... | 169,595,752 |

a Value included under "Miscellaneous."
b Included in Missouri figures. Not separable.

*Mineral production of Oregon in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons.. | (a) | (a) | 344 | $2,772 |
| Briquets, fuel.....do.... | (a b) | (a b) | (a b) | (a b) |
| Cement.....barrels.. | ..... | ..... | (a) | (a) |
| Chromic iron ore.....long tons.. | ..... | ..... | 3,099 | 37,806 |
| Clay products..... | ..... | c $341,243 | ..... | c 299,993 |
| Clay, raw.....short tons.. | (a b) | (a b) | (a b) | (a b) |
| Coal.....do.... | 39,231 | 111,240 | 42,592 | 113,976 |
| Copper.....pounds.. | 451,172 | 78,955 | 3,581,886 | 881,144 |
| Diatomaceous earth..... | ..... | (a) | ..... | ..... |
| Gems and precious stones..... | ..... | 4,252 | ..... | 4,402 |
| Gold.....fine ounces (troy).. | 90,064 | 1,861,796 | 92,018 | 1,902,179 |
| Gypsum.....short tons.. | (a) | (a) | (a) | (a) |
| Lead.....do.... | 31 | 2,959 | 14 | 1,932 |
| Lime.....do.... | 4,188 | 30,411 | 4,225 | 35,289 |
| Mineral waters.....gallons sold.. | 28,747 | 8,729 | 30,920 | 7,961 |
| Platinum and allied metals.....fine ounces (troy).. | (a) | (a) | 20 | 1,780 |
| Quicksilver.....flasks.. | (a) | (a) | (a) | (a) |
| Sand and gravel.....short tons.. | 880,633 | 301,425 | 904,078 | 283,493 |
| Silver.....fine ounces (troy).. | 117,947 | 57,799 | 231,342 | 152,223 |
| Stone..... | ..... | 753,285 | ..... | 443,524 |
| Miscellaneous..... | ..... | 245,973 | ..... | 415,544 |
| Total value, eliminating duplications..... | ..... | 3,656,562 | ..... | 4,498,632 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of pottery, value for which is included under "Miscellaneous."

*Mineral production of Pennsylvania in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Abrasives, artificial....pounds.. | (a b) | (a b) | (a b) | (a b) |
| Briquets, fuel....short tons.. | 20,561 | b $85,841 | 19,038 | b $73,000 |
| Cement....barrels.. | 28,230,027 | 20,267,414 | c28,748,546 | c 27,915,298 |
| Clay products.... | .... | 22,726,031 | .... | 32,110,690 |
| Clay, raw....short tons.. | 441,918 | b 735,321 | 577,147 | b 1,098,129 |
| Coal: | | | | |
| Anthracite....do.... | 88,995,061 | 184,653,498 | 87,578,493 | 202,009,561 |
| Bituminous....do.... | 157,955,137 | 167,419,705 | 170,295,424 | 221,685,175 |
| Coke....do.... | 25,622,862 | b 52,667,018 | 31,279,695 | b 84,710,305 |
| Copper....pounds.. | (a) | (a) | 625,000 | 153,750 |
| Feldspar....short tons.. | 6,395 | 47,025 | 7,342 | 56,323 |
| Ferroalloys....long tons.. | 207,936 | b 11,919,060 | 346,370 | b 34,494,480 |
| Gems and precious stones.... | .... | (a) | .... | 165 |
| Graphite, crystalline....pounds.. | (a) | (a) | 1,095,716 | 103,377 |
| Iron ore....long tons.. | 367,056 | 333,697 | 558,556 | 702,633 |
| Iron, pig....do.... | 12,779,974 | b174,926,891 | 16,351,131 | b 293,437,782 |
| Lead....short tons.. | (a) | (a) | .... | .... |
| Lime....do.... | 901,549 | 2,947,058 | 972,343 | 3,857,553 |
| Manganiferous ore....long tons.. | .... | .... | 451 | (a) |
| Marl, calcareous....short tons.. | .... | .... | (a) | (a) |
| Mica.... | .... | .... | .... | (a) |
| Millstones.... | .... | (a) | .... | (a) |
| Mineral paints: | | | | |
| Natural pigments....short tons.. | 21,116 | 191,891 | (d) | (d) |
| Zinc and lead pigments....do.... | (a) | (a) | (a) | (a) |
| Mineral waters....gallons sold.. | 2,136,218 | 174,798 | 1,671,637 | 145,123 |
| Natural gas.... | .... | 21,139,605 | .... | 24,344,324 |
| Natural-gas gasoline....gallons.. | 5,898,597 | 599,873 | 9,714,926 | 1,726,173 |
| Oilstones.... | .... | (a) | .... | (a) |
| Petroleum....barrels.. | 7,838,705 | 12,431,353 | 7,592,394 | 19,149,855 |
| Potash ($K_2O$)....short tons.. | .... | .... | (a) | (a) |
| Pyrite....long tons.. | (a) | (a) | (a) | (a) |
| Sand and gravel....short tons.. | 6,164,400 | 2,776,812 | 7,442,452 | 4,023,692 |
| Sand and sandstone (finely ground)....do.... | (a) | (a) | (a) | (a) |
| Sand-lime brick.... | .... | 56,848 | .... | 94,328 |
| Silica (quartz)....short tons.. | (a) | (a) | (a) | (a) |
| Slate.... | .... | 3,044,269 | .... | 3,124,743 |
| Stone.... | .... | 9,310,397 | .... | 11,021,655 |
| Sulphuric acid (60° Baumé) e....short tons.. | (a) | (a) | (a) | (a) |
| Talc....do.... | (a) | (a) | (a) | (a) |
| Tripoli.... | .... | (a) | .... | (a) |
| Miscellaneous.... | .... | 12,635,859 | .... | 21,843,436 |
| Total value, eliminating duplications.... | .... | 460,673,133 | .... | 573,978,305 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of natural cement and puzzolan, value for which is included under "Miscellaneous."
d Canvass discontinued.
e From zinc smelting.

*Mineral production of Rhode Island in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products.... | .... | (a) | .... | (a) |
| Graphite, amorphous....short tons.. | (a) | (a) | (a) | (a) |
| Lime....do.... | (a) | (a) | (a) | (a) |
| Mineral waters....gallons sold.. | 385,624 | $24,574 | 449,453 | $33,050 |
| Sand and gravel....short tons.. | (a) | (a) | (a) | (a) |
| Soapstone....do.... | (a) | (a) | (a) | (a) |
| Stone.... | .... | 693,950 | .... | 632,452 |
| Miscellaneous.... | .... | 136,483 | .... | 123,706 |
| Total value, eliminating duplications.... | .... | 855,007 | .... | 789,208 |

a Value included under "Miscellaneous."

*Mineral production of South Carolina in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Barytes.....short tons.. | (a) | (a) | (a) | (a) |
| Clay products..... | ..... | $379,133 | ..... | $607,151 |
| Clay, raw.....short tons.. | 24,854 | b 119,218 | 32,881 | b 170,070 |
| Gems and precious stones..... | ..... | (a) | ..... | ..... |
| Gold.....fine ounces (troy).. | 183 | 3,789 | 15 | 320 |
| Lime.....short tons.. | (a) | (a) | ..... | ..... |
| Marl, calcareous.....do... | ..... | ..... | (a) | (a) |
| Mica..... | ..... | (a) | ..... | (a) |
| Mineral waters.....gallons sold.. | 480,051 | 67,869 | 427,905 | 63,818 |
| Phosphate rock.....long tons.. | 83,460 | 310,850 | 53,047 | 211,125 |
| Pyrite.....do.... | (a) | (a) | (a) | (a) |
| Sand and gravel.....short tons.. | 109,011 | 21,440 | 54,018 | 21,211 |
| Silver.....fine ounces (troy).. | 8 | 4 | 28 | 18 |
| Stone..... | ..... | 321,612 | ..... | 447,940 |
| Miscellaneous..... | ..... | 25,012 | ..... | 40,490 |
| Total value, eliminating duplications..... | ..... | 1,129,709 | ..... | 1,392,073 |

a Value included under "Miscellaneous."
b Value not included in total value.

*Mineral production of South Dakota in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons.. | (a) | (a) | ..... | ..... |
| Clay products..... | ..... | $36,342 | ..... | $115,474 |
| Coal.....short tons.. | 10,593 | 16,384 | 8,886 | 18,021 |
| Gems and precious stones..... | ..... | (a) | ..... | ..... |
| Gold.....fine ounces (troy).. | 358,280 | 7,406,305 | 360,909 | 7,460,644 |
| Gypsum.....short tons.. | (a) | (a) | (a) | (a) |
| Lead.....do.... | 2 | 146 | 18 | 2,443 |
| Lime.....do.... | 5,625 | 34,728 | 5,772 | 44,033 |
| Lithium minerals.....do.... | (a) | (a) | 548 | 10,970 |
| Mica..... | ..... | 10,914 | ..... | 59,770 |
| Mineral waters.....gallons sold.. | 176,000 | 9,360 | 470,725 | 20,512 |
| Natural gas..... | ..... | (a) | ..... | (a) |
| Pyrite.....long tons.. | ..... | ..... | 145 | 966 |
| Sand and gravel.....short tons.. | 256,270 | 45,717 | 1,096,594 | 133,755 |
| Sand-lime brick..... | ..... | 18,402 | ..... | 32,139 |
| Silver.....fine ounces (troy).. | 199,864 | 101,331 | 215,205 | 141,605 |
| Stone..... | ..... | 159,089 | ..... | 205,497 |
| Tungsten ore (60 per cent concentrates)....short tons.. | 140 | 181,089 | 239 | 404,775 |
| Miscellaneous..... | ..... | 73,863 | ..... | 46,076 |
| Total value, eliminating duplications..... | ..... | 8,093,670 | ..... | 8,695,680 |

a Value included under "Miscellaneous."

*Mineral production of Tennessee in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Aluminum....pounds.. | (a b) | (a b) | (a b) | (a b) |
| Barytes....short tons.. | 25,074 | $71,390 | 32,416 | $123,986 |
| Bauxite....long tons.. | (a) | (a) | (a) | (a) |
| Cement....barrels.. | (a) | (a) | (a) | (a) |
| Clay products.... | .... | 1,548,220 | .... | 1,983,957 |
| Clay, raw....short tons.. | 59,975 | b 123,132 | 101,617 | b 209,951 |
| Coal....do.... | 5,730,361 | 6,479,016 | 6,137,449 | 7,522,445 |
| Coke....do.... | 256,973 | b 674,014 | 382,175 | b 1,062,065 |
| Copper....pounds.. | 18,046,010 | 3,158,051 | 14,679,794 | 3,611,229 |
| Ferroalloys....long tons.. | (a b) | (a b) | 12,966 | (a b) |
| Gold....fine ounces (troy).. | 332 | 6,862 | 278 | 5,739 |
| Iron ore....long tons.. | 283,841 | 408,304 | 467,741 | 736,397 |
| Iron, pig....do.... | 208,298 | b 2,519,337 | 329,342 | b 4,981,538 |
| Lead....short tons.. | 1 | 78 | 16 | 2,274 |
| Lime....do.... | 82,765 | 256,069 | 109,533 | 378,017 |
| Manganese ore....long tons.. | .... | .... | 212 | 5,459 |
| Manganiferous ore....do.... | (a) | (a) | (a) | (a) |
| Mineral paints, natural pigments....short tons.. | (a) | (a) | (c) | (c) |
| Mineral waters....gallons sold.. | 708,566 | 39,304 | 799,346 | 48,416 |
| Natural gas.... | .... | 400 | .... | 1,150 |
| Petroleum....barrels.. | .... | .... | 677 | 1,317 |
| Phosphate rock....long tons.. | 389,748 | 1,327,687 | 409,803 | 1,500,418 |
| Pyrite....do.... | .... | .... | (a) | (a) |
| Sand and gravel....short tons.. | 1,015,055 | 376,826 | 1,092,270 | 414,225 |
| Silica (quartz)....do.... | (a) | (a) | (a) | (a) |
| Silver....fine ounces (troy).. | 100,543 | 50,975 | 94,701 | 62,313 |
| Stone.... | .... | 1,814,782 | .... | 1,753,180 |
| Sulphuric acid (60° Baumé) d....short tons.. | (a) | (a) | (a) | (a) |
| Zinc....do.... | 16,461 | 4,082,440 | 26,428 | 7,062,634 |
| Miscellaneous.... | .... | 5,085,310 | .... | 9,901,207 |
| Total value, eliminating duplications.... | .... | 22,166,494 | .... | 28,277,365 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Canvass discontinued.
d From copper smelting.

*Mineral production of Texas in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asphalt: | | | | |
| Natural....short tons.. | (a) | (a) | (a) | (a) |
| Oil....do.... | 98,813 | $1,263,757 | 127,259 | $1,631,920 |
| Cement....barrels.. | 1,932,828 | 2,518,233 | 2,327,659 | 3,177,104 |
| Clay products.... | .... | 1,976,890 | .... | 2,837,960 |
| Clay, raw....short tons.. | 3,204 | b 10,610 | 2,936 | b 10,531 |
| Coal....do.... | 2,068,908 | 3,445,487 | 1,987,503 | 3,092,663 |
| Copper....pounds.. | 42,491 | 7,436 | 99,569 | 24,494 |
| Fuller's earth....short tons.. | (a) | (a) | (a) | (a) |
| Gems and precious stones.... | .... | (a) | .... | 908 |
| Gold....fine ounces (troy).. | 73 | 1,503 | 20 | 414 |
| Graphite, crystalline....pounds.. | .... | .... | (a) | (a) |
| Gypsum....short tons.. | 176,306 | 519,879 | 197,785 | 653,288 |
| Lead....do.... | 110 | 10,307 | 25 | 3,445 |
| Lime....do.... | 39,468 | 211,516 | 54,049 | 307,759 |
| Manganese ore....long tons.. | (a) | (a) | (a) | (a) |
| Mineral waters....gallons sold.. | 835,142 | 100,090 | 703,002 | 97,513 |
| Natural gas.... | .... | 2,593,873 | .... | 3,143,871 |
| Natural-gas gasoline....gallons.. | (a) | (a) | 1,202,811 | 201,023 |
| Petroleum....barrels.. | 24,942,701 | 13,026,925 | 27,644,605 | 25,760,335 |
| Quicksilver....flasks.. | (a) | (a) | 6,306 | 793,862 |
| Salt....short tons.. | 62,297 | 345,944 | 75,762 | 427,119 |
| Sand and gravel....do.... | 1,912,303 | 533,808 | 2,617,409 | 957,794 |
| Sand-lime brick.... | .... | 52,941 | .... | 45,092 |
| Silver....fine ounces (troy).. | 675,473 | 342,465 | 653,455 | 429,973 |
| Stone.... | .... | 726,323 | .... | 698,449 |
| Sulphur....long tons.. | (a) | (a) | (a) | (a) |
| Zinc....short tons.. | 15 | 3,769 | 116 | 31,140 |
| Miscellaneous.... | .... | 1,539,805 | .... | 3,395,445 |
| Total value, eliminating duplications.... | .... | 29,220,951 | .... | 47,711,571 |

a Value included under "Miscellaneous."
b Value not included in total value.

*Mineral production of Utah in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons.. | (a) | (a) | 73 | $590 |
| Asphalt.....do.... | 21,709 | $281,002 | 26,874 | 633,440 |
| Cement.....barrels.. | 655,116 | 823,995 | 892,506 | 1,467,564 |
| Clay products..... | ..... | [b] 699,962 | ..... | [b] 885,357 |
| Clay, raw.....short tons.. | 5,398 | [c] 8,807 | (a c) | (a c) |
| Coal.....do.... | 3,108,715 | 4,916,916 | 3,567,428 | 5,795,944 |
| Coke.....do.... | (a c) | (a c) | (a c) | (a c) |
| Copper.....pounds.. | 187,671,188 | 32,842,458 | 240,275,222 | 59,107,705 |
| Gems and precious stones..... | ..... | 3,617 | ..... | 3,265 |
| Gold.....fine ounces (troy).. | 174,591 | 3,609,109 | 172,938 | 3,574,947 |
| Gypsum.....short tons.. | 23,445 | 75,835 | 27,727 | 83,994 |
| Iron ore.....long tons.. | (a) | (a) | 45,514 | (a) |
| Lead.....short tons.. | 99,984 | 9,398,470 | 100,745 | 13,902,815 |
| Lime.....do.... | 11,460 | 67,273 | 12,472 | 77,133 |
| Manganese ore.....long tons.. | (a) | (a) | 1,282 | 22,597 |
| Manganiferous ore.....do.... | 55 | (a) | (a) | (a) |
| Mineral waters.....gallons sold.. | (a) | (a) | (a) | (a) |
| Molybdenum.....pounds.. | ..... | ..... | 824 | 800 |
| Phosphate rock.....long tons.. | (a) | (a) | (a) | (a) |
| Potash ($K_2O$).....short tons.. | ..... | ..... | (a) | (a) |
| Salt.....do.... | 55,279 | 266,334 | 60,653 | 289,457 |
| Sand and gravel.....do.... | 261,611 | 32,197 | 185,569 | 24,048 |
| Silver.....fine ounces (troy).. | 12,313,205 | 6,242,795 | 13,253,037 | 8,720,498 |
| Slate..... | ..... | (a) | ..... | (a) |
| Stone..... | ..... | 288,398 | ..... | 368,705 |
| Tungsten ore (60 per cent concentrates)....short tons.. | (a) | (a) | 20 | 29,766 |
| Uranium and vanadium ores.....do.... | ..... | (a) | ..... | 10,000 |
| Zinc.....do.... | 12,146 | 3,012,238 | 14,786 | 3,962,719 |
| Miscellaneous..... | ..... | 1,642,567 | ..... | 2,551,809 |
| Total value, eliminating duplications..... | ..... | 62,586,261 | ..... | 99,734,209 |

[a] Value included under "Miscellaneous."
[b] Exclusive of pottery, value for which is included under "Miscellaneous."
[c] Value not included in total value.

*Mineral production of Vermont in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Clay products..... | ..... | $71,642 | ..... | $94,779 |
| Clay, raw.....short tons.. | 5,388 | [a] 37,061 | 5,397 | [a] 40,684 |
| Copper.....pounds.. | (b) | (b) | (b) | (b) |
| Feldspar.....short tons.. | ..... | ..... | (b) | (b) |
| Lime.....do.... | 37,992 | 187,144 | 43,365 | 236,133 |
| Mineral paint, natural pigments.....do.... | (b) | (b) | (c) | (c) |
| Mineral waters.....gallons sold.. | 61,540 | 14,382 | 72,590 | 15,395 |
| Sand and gravel.....short tons.. | 76,590 | 23,942 | 68,892 | 34,481 |
| Scythestones..... | ..... | (b) | ..... | (b) |
| Silver.....fine ounces (troy).. | 353 | 179 | 2,501 | 1,646 |
| Slate..... | ..... | 1,234,891 | ..... | 1,607,901 |
| Stone..... | ..... | 5,620,899 | ..... | 5,691,420 |
| Talc and soapstone.....short tons.. | 62,497 | 409,652 | 73,215 | 501,175 |
| Miscellaneous..... | ..... | 23,679 | ..... | 75,918 |
| Total value, eliminating duplications..... | ..... | 7,586,410 | ..... | 8,258,848 |

[a] Value not included in total value.
[b] Value included in "Miscellaneous."
[c] Canvass discontinued.

*Mineral production of Virginia in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Asbestos.....short tons | ..... | ..... | (a) | (a) |
| Barytes.....do | (a) | (a) | (a) | (a) |
| Briquets, fuel.....do | (a b) | (a b) | (a b) | (a b) |
| Cement.....barrels | (a) | (a) | (a) | (a) |
| Clay products..... | ..... | c $1,447,802 | ..... | c $1,676,723 |
| Clay, raw.....short tons | 4,958 | b 4,333 | (a b) | (a b) |
| Coal.....do | 8,122,596 | 7,962,934 | 9,707,474 | 10,261,424 |
| Coke.....do | 629,807 | b 1,242,938 | 1,242,332 | b 3,024,913 |
| Copper.....pounds | 27,744 | 4,855 | 553,800 | 136,235 |
| Diatomaceous earth..... | ..... | (a) | ..... | ..... |
| Feldspar.....short tons | (a) | (a) | (a) | (a) |
| Gems and precious stones..... | ..... | (a) | ..... | 565 |
| Gold.....fine ounces (troy) | 26 | 534 | 43 | 885 |
| Gypsum.....short tons | (a) | (a) | (a) | (a) |
| Iron ore.....long tons | 334,424 | 696,920 | 486,798 | 1,000,118 |
| Iron, pig.....do | 265,616 | b 3,408,784 | 444,491 | b 7,140,002 |
| Lead.....short tons | 339 | 31,901 | 728 | 100,453 |
| Lime.....do | 267,278 | 840,969 | 326,812 | 1,279,658 |
| Manganese ore.....long tons | 1,620 | 17,988 | 4,388 | 118,139 |
| Manganiferous ore.....do | 1,944 | 6,708 | 37,729 | 104,997 |
| Marl, calcareous.....short tons | ..... | ..... | (a) | (a) |
| Mica..... | ..... | 10,418 | ..... | 20,954 |
| Millstones..... | ..... | 23,170 | ..... | 25,752 |
| Mineral paints, natural pigments.....short tons | (a) | (a) | (d) | (d) |
| Mineral waters.....gallons sold | 3,027,528 | 237,818 | 2,313,616 | 248,906 |
| Pyrite.....long tons | 145,050 | 729,644 | 148,502 | 925,243 |
| Salt.....short tons | (a) | (a) | (a) | (a) |
| Sand and gravel.....do | 870,219 | 234,112 | 641,595 | 226,373 |
| Sand and sandstone (finely ground).....do | (a) | (a) | ..... | ..... |
| Silica (quartz).....do | ..... | ..... | (a) | (a) |
| Silver.....fine ounces (troy) | ..... | ..... | 783 | 515 |
| Slate..... | ..... | 210,612 | ..... | 165,483 |
| Stone..... | ..... | 2,586,427 | ..... | 1,605,161 |
| Talc and soapstone.....short tons | 22,741 | 504,742 | 28,355 | 564,228 |
| Titanium minerals: | | | | |
| Ilmenite.....do | 250 | 27,500 | 95 | 1,900 |
| Rutile.....do | | | 110 | 16,500 |
| Zinc.....do | 1,267 | 314,113 | 2,276 | 609,866 |
| Miscellaneous..... | ..... | 1,110,119 | ..... | 1,501,455 |
| Total value, eliminating duplications..... | ..... | 16,994,786 | ..... | 20,560,956 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of pottery, value for which is included under "Miscellaneous."
d Canvass discontinued.

*Mineral production of Washington in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Antimony ore.....short tons.. | (a) | (a) | 400 | $3,355 |
| Briquets, fuel.....do.... | (a b) | (a b) | (a b) | (a b) |
| Cement.....barrels.. | 1,378,107 | $1,790,499 | 1,575,919 | 2,447,779 |
| Clay products..... | ..... | c 1,454,436 | ..... | c 1,589,574 |
| Clay, raw.....short tons.. | 829 | b 4,340 | 1,840 | b 6,251 |
| Coal.....do.... | 2,429,095 | 5,276,299 | 3,038,588 | 6,907,428 |
| Coke.....do.... | 136,552 | b 700,832 | (a b) | (a b) |
| Copper.....pounds.. | 1,020,926 | 178,662 | 2,645,022 | 650,675 |
| Diatomaceous earth..... | ..... | 14,515 | ..... | 10,700 |
| Gems and precious stones..... | ..... | ..... | ..... | 850 |
| Gold.....fine ounces (troy).. | 18,935 | 391,419 | 27,944 | 577,655 |
| Lead.....short tons.. | 148 | 13,875 | 2,700 | 372,550 |
| Lime.....do.... | 27,240 | 171,023 | 26,895 | 166,653 |
| Magnesite.....do.... | ..... | ..... | 715 | 5,362 |
| Manganese ore.....long tons.. | ..... | ..... | (a) | (a) |
| Manganiferous ore.....do.... | ..... | ..... | (a) | (a) |
| Mineral paints, natural pigments.....short tons.. | (a) | (a) | (d) | (d) |
| Mineral waters.....gallons sold.. | 158,865 | 11,703 | 151,528 | 9,476 |
| Potash ($K_2O$).....short tons.. | ..... | ..... | (a) | (a) |
| Quicksilver.....flasks.. | ..... | ..... | (a) | (a) |
| Sand and gravel.....short tons.. | 772,629 | 211,480 | 1,401,237 | 387,337 |
| Sand-lime brick..... | ..... | (a) | ..... | (a) |
| Silica (quartz).....short tons.. | ..... | ..... | (a) | (a) |
| Silver.....fine ounces (troy).. | 255,837 | 129,709 | 335,121 | 220,510 |
| Stone..... | ..... | 1,758,817 | ..... | 903,635 |
| Strontium.....short tons.. | ..... | ..... | (a) | (a) |
| Tungsten ore (60 per cent concentrates).....do.... | (a) | (a) | 11 | 15,230 |
| Zinc.....do.... | 122 | 30,368 | 847 | 226,960 |
| Miscellaneous..... | ..... | 229,070 | ..... | 1,046,792 |
| Total value, eliminating duplications..... | ..... | 11,455,715 | ..... | 14,521,014 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of pottery, value for which is included under "Miscellaneous."
d Canvass discontinued.

*Mineral production of West Virginia in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Bromine.....pounds.. | 130,397 | $196,388 | 136,544 | $179,126 |
| Calcium chloride.....short tons.. | 4,559 | 25,754 | 5,924 | 42,263 |
| Cement.....barrels.. | (a) | (a) | (a) | (a) |
| Clay products..... | ..... | 6,284,527 | ..... | 7,634,321 |
| Clay, raw.....short tons.. | 85,103 | b 59,610 | 122,944 | b 126,283 |
| Coal.....do.... | 77,184,069 | 74,561,349 | 86,460,127 | 102,366,092 |
| Coke.....do.... | 1,391,446 | b 2,760,805 | 2,521,309 | b 6,567,505 |
| Grindstones..... | ..... | (a) | ..... | (a) |
| Iron ore.....long tons.. | ..... | ..... | 3,605 | (a) |
| Iron, pig.....do.... | (a b) | (a b) | 348,743 | (a b) |
| Lime.....short tons.. | 250,000 | 896,520 | 277,721 | 1,008,021 |
| Mineral waters.....gallons sold.. | 314,909 | 50,271 | 287,466 | 46,686 |
| Natural gas..... | ..... | 36,424,263 | ..... | 47,603,396 |
| Natural-gas gasoline.....gallons.. | 10,853,608 | 927,079 | 18,765,056 | 3,025,293 |
| Petroleum.....barrels.. | 9,264,798 | 14,468,278 | 8,731,184 | 21,914,080 |
| Salt.....short tons.. | 32,513 | 115,143 | 33,389 | 122,669 |
| Sand and gravel.....do.... | 723,354 | 479,085 | 1,054,878 | 777,952 |
| Sand and sandstone (finely ground).....do.... | (a) | (a) | (a) | (a) |
| Stone..... | ..... | 1,047,095 | ..... | 1,500,809 |
| Miscellaneous..... | ..... | 3,033,745 | ..... | 6,470,753 |
| Total value, eliminating duplications..... | ..... | 136,070,173 | ..... | 187,043,011 |

a Value included under "Miscellaneous." b Value not included in total value.

*Mineral production of Wisconsin in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Briquets, fuel.....short tons | (a b) | (a b) | (a b) | (a b) |
| Clay products | ..... | $910,558 | ..... | c $905,910 |
| Clay, raw.....short tons | 310 | b 413 | (a b) | (a b) |
| Coke.....do | (a b) | (a b) | (a b) | (a b) |
| Graphite, amorphous.....do | (a) | (a) | ..... | ..... |
| Iron ore.....long tons | 1,125,269 | 2,188,012 | 1,529,459 | 3,614,542 |
| Iron, pig.....do | 302,913 | b 3,997,940 | 423,973 | b 7,534,327 |
| Lead.....short tons | 2,322 | 218,268 | 3,043 | 419,934 |
| Lime.....do | 221,147 | 755,986 | 266,805 | 1,207,050 |
| Manganiferous ore.....long tons | 10,616 | (a) | 3,982 | (a) |
| Mineral paints: | | | | |
| Natural pigments.....short tons | 4,017 | 53,547 | d 1,791 | (a) |
| Zinc and lead pigments.....do | (a) | (a) | (a) | (a) |
| Mineral waters.....gallons sold | 4,861,734 | 1,051,405 | 7,696,813 | 1,507,679 |
| Potash ($K_2O$).....short tons | ..... | ..... | 125 | 67,625 |
| Pyrite.....long tons | 13,985 | 43,354 | (a) | (a) |
| Sand and gravel.....short tons | 2,862,036 | 689,915 | 3,544,766 | 894,202 |
| Sand-lime brick | ..... | 94,064 | ..... | (a) |
| Silica (quartz).....short tons | (a) | (a) | (a) | (a) |
| Stone | ..... | 2,412,741 | ..... | 2,757,790 |
| Sulphuric acid e.....short tons | ..... | ..... | (a) | (a) |
| Zinc.....do | 41,403 | 10,267,944 | 56,803 | 15,223,204 |
| Miscellaneous | ..... | 4,023,207 | ..... | 5,258,562 |
| Total value, eliminating duplications | ..... | 19,795,588 | ..... | 28,304,675 |

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of pottery, value for which is included under "Miscellaneous."
d Iron ore sold for paint. General canvass of mineral paint industry discontinued.
e From zinc smelting.

*Mineral production of Wyoming in 1915 and 1916.*

| Product. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| Chromic iron ore.....long tons | ..... | ..... | (a) | (a) |
| Clay products | ..... | $57,021 | ..... | $90,199 |
| Clay, raw.....short tons | (a b) | (a b) | (a b) | (a b) |
| Coal.....do | 6,554,028 | 9,555,804 | 7,910,647 | 12,239,707 |
| Copper.....pounds | 447,246 | 78,268 | 2,610,622 | 642,213 |
| Gems and precious stones | ..... | (a) | ..... | (a) |
| Gold.....fine ounces (troy) | 706 | 14,592 | 995 | 20,566 |
| Gypsum.....short tons | 38,827 | 103,110 | 46,964 | 141,408 |
| Iron ore.....long tons | 434,513 | (a) | 545,774 | (a) |
| Lime.....short tons | (a) | (a) | (a) | (a) |
| Mineral waters.....gallons sold | 68,584 | 9,059 | 53,891 | 7,269 |
| Natural gas | ..... | (a) | ..... | (a) |
| Petroleum.....barrels | 4,245,525 | 2,217,018 | 6,234,137 | 5,644,080 |
| Phosphate rock.....long tons | (a) | (a) | (a) | (a) |
| Platinum and allied metals.....fine ounces (troy) | (a) | (a) | (a) | (a) |
| Sand and gravel.....short tons | 526,837 | 49,439 | 769,739 | 86,972 |
| Silver.....fine ounces (troy) | 840 | 426 | 5,524 | 3,635 |
| Stone | ..... | 70,576 | ..... | 64,509 |
| Sulphur.....long tons | (a) | (a) | (a) | (a) |
| Miscellaneous | ..... | 554,400 | ..... | 728,390 |
| Total value, eliminating duplications | ..... | 12,708,238 | ..... | 19,666,988 |

a Value included under "Miscellaneous." b Value not included in total value.

# PREFATORY NOTE TO THE REPORTS ON GOLD, SILVER, COPPER, LEAD, AND ZINC.

By H. D. McCaskey.

In the mining industry five metals are closely related in both the genesis and the geologic occurrence of their ores. They also hold together in mining and in metallurgical treatment. They are gold, silver, copper, lead, and zinc. Of their ores some contain all five metals, many contain three or four, and few contain only one. Gold and silver, for instance, on the one hand, and lead and zinc, on the other, almost always stand in close genetic relations, and the ores of each two are usually mined together. Copper ores almost invariably produce some silver and gold as well as copper, and lead ores, with certain exceptions, produce notable supplies of silver. Zinc ores in the Western States contribute also to the silver production. In the same mines sometimes, and in the same mining district frequently all five metals occur in commercial quantity.

This situation is recognized by the United States Geological Survey in its publication of the annual reports on the mineral resources of the country. Hence the general treatment of each of the five metals in the general reports and the grouping together of the related metals in the various mines reports descriptive of individual or geographically grouped States.

To facilitate advance publication, the complete report upon these five metals is therefore divided into 16 sections, each of which is published separately. The first 4 sections give figures of output for the calendar year in marketable form for the metals named as obtained from the smelters, refineries, and mints, and general reviews of the respective industries for the entire country. The last 12 sections give the production (called "mine production") as obtained from the mines so far as possible in terms of recoverable metal in ores and other material sold or treated during the calendar year and supply information in detail relative to the mining industry in the respective States, counties, and mining districts. The figures given in the general reports are the final official statistics of the production of the country and of the States. The general report on gold and silver includes the statistics of recovered precious metals as determined jointly by the Bureau of the Mint and the United States Geological Survey.

The 16 sections, which appear as separate chapters in this volume, are as follows:

Gold and silver (general report).
Copper (general report).
Lead (general report).
Zinc (general report).
Gold, silver, copper, lead, and zinc in the Eastern States (mines report).
Silver, copper, lead, and zinc in the Central States (mines report).
Gold, silver, and copper in Alaska (mines report).
Gold, silver, copper, lead, and zinc in Arizona (mines report).
Gold, silver, copper, lead, and zinc in California and Oregon (mines report).
Gold, silver, copper, lead, and zinc in Colorado (mines report).
Gold, silver, copper, lead, and zinc in Idaho and Washington (mines report).
Gold, silver, copper, lead, and zinc in Montana (mines report).
Gold, silver, copper, lead, and zinc in Nevada (mines report).
Gold, silver, copper, lead, and zinc in New Mexico and Texas (mines report).
Gold, silver, copper, and lead in South Dakota and Wyoming (mines report).
Gold, silver, copper, lead, and zinc in Utah (mines report).

In measurements of ores, concentrates, and similar material the short ton of 2,000 pounds is used throughout. The ore classification is necessarily arbitrary in part. An ore is generally understood to be worked at a profit for one or more metals. The complex nature of western ores especially and the graduations from one well-recognized class to another render essential some fixed measures for the terminology used. The dry or siliceous ores comprise gold and silver ores proper, fluxing ores carrying considerable quantities of iron and manganese oxides and very small quantities of gold and silver, as well as precious metal bearing ores carrying copper, lead, or zinc in quantities too small to justify their classification as copper, lead, zinc, or mixed ores. The copper ores include those carrying over 2½ per cent of copper, and some carrying even less, such as the great disseminated copper deposits of the West and the copper ores of the Lake Superior region. In general, the lead ores are those containing over 4½ per cent of lead, and the zinc ores are those containing 25 per cent or more of zinc, both irrespective of their precious metal content; but some ores of lower grade in lead, and especially in zinc, are treated profitably for these metals, and of course they are then classified as lead or zinc ores, as the case may be. The mixed ores are combinations of the ones enumerated.

The prices used by the United States Geological Survey for calculation of values for the years 1850–1916, inclusive, are as follows:

*Prices of silver, copper, lead, and zinc, 1850–1916.*

| Year. | Silver.[a] | Copper.[b] | Lead.[c] | Zinc.[d] | Year. | Silver.[a] | Copper.[b] | Lead.[c] | Zinc.[d] |
|---|---|---|---|---|---|---|---|---|---|
| | *Fine ounce.* | *Pound.* | *Pound.* | *Pound.* | | *Fine ounce.* | *Pound.* | *Pound.* | *Pound.* |
| 1850 | $1.32 | $0.22 | $0.05 | ..... | 1884 | $1.11 | $0.13 | $0.037 | $0.044 |
| 1851 | 1.34 | .166 | .05 | ..... | 1885 | 1.07 | .108 | .040 | .043 |
| 1852 | 1.33 | .22 | .05 | ..... | 1886 | .99 | .111 | .046 | .044 |
| 1853 | 1.35 | .22 | .06 | $0.055 | 1887 | .98 | .138 | .045 | .046 |
| 1854 | 1.35 | .22 | .06 | ..... | 1888 | .94 | .168 | .044 | .049 |
| 1855 | 1.34 | .27 | .07 | ..... | 1889 | .94 | .135 | .039 | .05 |
| 1856 | 1.34 | .27 | .066 | ..... | 1890 | 1.06 | .156 | .045 | .055 |
| 1857 | 1.35 | .25 | .06 | ..... | 1891 | .99 | .128 | .043 | .05 |
| 1858 | 1.34 | .23 | .06 | ..... | 1892 | .87 | .116 | .041 | .046 |
| 1859 | 1.36 | .22 | .055 | ..... | 1893 | .78 | .108 | .037 | .04 |
| 1860 | 1.35 | .23 | .056 | ..... | 1894 | .63 | .035 | .033 | .035 |
| 1861 | 1.33 | .22 | .05 | ..... | 1895 | .65 | .107 | .032 | .036 |
| 1862 | 1.35 | .22 | .06 | ..... | 1896 | .68 | .108 | .03 | .039 |
| 1863 | 1.345 | .34 | .06 | ..... | 1897 | .60 | .12 | .036 | .041 |
| 1864 | 1.345 | .47 | .07 | .139 | 1898 | .59 | .124 | .038 | .046 |
| 1865 | 1.337 | .332 | .066 | ..... | 1899 | .60 | .171 | .045 | .058 |
| 1866 | 1.339 | .342 | .07 | ..... | 1900 | .62 | .166 | .044 | .044 |
| 1867 | 1.33 | .254 | .065 | ..... | 1901 | .60 | .167 | .043 | .041 |
| 1868 | 1.326 | .23 | .055 | ..... | 1902 | .53 | .122 | .041 | .048 |
| 1869 | 1.325 | .242 | .06 | ..... | 1903 | .54 | .137 | .042 | .054 |
| 1870 | 1.328 | .212 | .06 | ..... | 1904 | .58 | .128 | .043 | .051 |
| 1871 | 1.325 | .241 | .06 | ..... | 1905 | .61 | .156 | .047 | .059 |
| 1872 | 1.322 | .376 | .054 | ..... | 1906 | .68 | .193 | .057 | .061 |
| 1873 | 1.297 | .280 | .06 | ..... | 1907 | .66 | .20 | .053 | .059 |
| 1874 | 1.278 | .220 | .06 | ..... | 1908 | .53 | .132 | .042 | .047 |
| 1875 | 1.24 | .227 | .058 | .07 | 1909 | .52 | .13 | .043 | .054 |
| 1876 | 1.16 | .21 | .051 | .072 | 1910 | .54 | .127 | .044 | .054 |
| 1877 | 1.20 | .19 | .055 | .06 | 1911 | .53 | .125 | .045 | .057 |
| 1878 | 1.15 | .166 | .036 | .049 | 1912 | .615 | .165 | .045 | .060 |
| 1879 | 1.12 | .186 | .041 | .052 | 1913 | .604 | .155 | .044 | .056 |
| 1880 | 1.15 | .214 | .05 | .055 | 1914 | .553 | .133 | .039 | .051 |
| 1881 | 1.13 | .182 | .048 | .072 | 1915 | .507 | .175 | .047 | .124 |
| 1882 | 1.14 | .191 | .049 | .053 | 1916 | .658 | .246 | .069 | .134 |
| 1883 | 1.11 | .165 | .043 | .045 | | | | | |

[a] Report of Director of the Mint, pp. 212–213, 1914. Equivalent value of fine ounce based on average price and average rate of exchange.

[b] Weed, W. H., Copper handbook, vol. 11, pp. 1339, 1343, for years 1850–1903. By computation from data for years 1850–1860, p. 1339. Survey computations for electrolytic copper since 1904. Figures for 1916 represent sales price of all marketable grades.

[c] New York price, Ingalls, W. R., Lead and zinc in the United States, p. 203, 1908. U. S. Geological Survey since 1904. Figures for 1916 represent average selling price for lead.

[d] New York price, 1875–1904, Ingalls, W. R., Lead and zinc in the United States, p. 342, 1908. St. Louis price, U. S. Geological Survey since 1904. The zinc prices for 1915 and 1916 are average sales prices for spelter, all grades. Oral communications from C. E. Siebenthal for 1853 and 1864.

It is to be understood, of course, that market values are not received by producers for metals in ore and intermediate products, nor always for metals in marketable form, that payment is made in accordance with contracts for treatment or sale, and that, therefore, average daily quotations do not necessarily agree with average prices received.

Each of the 16 sections mentioned is published in a separate pamphlet for advance distribution, and copies can be obtained, as long as the supply lasts, on request made to the Director, United States Geological Survey, Washington, D. C.

# PLATINUM AND ALLIED METALS.

By JAMES M. HILL.

## INTRODUCTION.

People are apt to think carelessly of platinum as a good setting for precious stones; the metal is, in fact, indispensable to many of our industries. Dishes and utensils of platinum are absolutely necessary in chemical laboratories, and on their laboratories all great industries depend for guidance. Alloys have been developed for some parts of the ignition systems of internal-combustion engines, but no substitute for platinum has been found for certain delicate parts of these systems. Platinum or allied rare metals have wide application in many instruments of precision used in the physical testing of all kinds of materials. Probably the most important use of platinum at present is in the contact process of making concentrated sulphuric acid, an essential commodity to many industries aside from its use in the manufacture of munitions.

The United States alone apparently uses about 165,000 fine ounces of platinum a year. The known supply of platinum is small; possibly 5,000,000 ounces have been produced in the world to date. Estimates based on the official figures of production from Russia since 1843 (which are taken as 25 per cent low) and on the assumption that Russia has supplied 95 per cent of the world's output indicate that the total quantity of crude placer platinum produced in the world since 1843 has been less than 4,632,000 troy ounces, or about 159 short tons.

Probably 500,000 ounces of this total output of platinum is in use as a catalyzing agent. The quantity manufactured in the form of chemical and physical equipment can not be readily ascertained but may be roughly estimated at 1,000,000 ounces. Electrical devices may have required 500,000 ounces, but perhaps 250,000 ounces would cover that use. The jewelry industry has probably consumed 1,000,000 ounces, and the dental industry also about 1,000,000 ounces. Minor uses and hoarded platinum will account for the remainder of the total supply derived from the known placer deposits.

Realizing the urgent necessity of increasing the domestic production of the metals of the platinum group, the United States Geological Survey has enlarged its field of investigation of the domestic platiniferous deposits. At the request of the Secretary of Commerce the Geological Survey will also take a census of all unmanufactured and scrap platinum in the United States that can be considered as an immediately available supply. It is confidently hoped that this census will show that the United States has a sufficient reserve of platinum to meet all the immediate needs of industry. The use of

platinum in heavy articles of jewelry will be curtailed, if the resolutions adopted by the Jewelers' Vigilance Committee [1] are applied by the manufacturing jewelers, as is to be expected in the present circumstances. This action will release a considerable supply of metal for the urgent needs of the chemists, which have recently been expressed in the form of a resolution [2] at the St. Louis meeting of the American Chemical Society.

## DOMESTIC PRODUCTION.

### CRUDE PLATINUM.

The production of crude platinum in California and Oregon in 1916, as reported by miners, was 710 troy ounces, valued at $35,490. Buyers and refiners, however, report purchases of 890 ounces of crude platinum from these States, which, at the average price of crude platinum ($45.50 an ounce), would have a value of $40,495. Production of crude platinum was reported by 7 dredges in Butte, by 2 dredges each in Calaveras, Yuba, and Sacramento counties, and by 1 dredge each in Stanislaus and Trinity counties, Cal., and in the Sumpter district, Baker County, Oreg. Nine hydraulic mines in California and 2 in Oregon reported saving platinum, and 2 sluice operators in each State reported sales of crude platinum.

Reports from refiners of platinum indicate that 25,945 ounces of foreign crude platinum were refined. Most of this material came from Colombia and a little from British Columbia.

### REFINED PLATINUM.

Reports received from the refiners of platinum, gold bullion, and blister copper indicate that 28,088 troy ounces of refined new metals of the platinum group were recovered, of which about 3,179 troy ounces are believed to be of domestic origin.

*New platinum and allied metals recovered by refiners, 1914–1916, in troy ounces.*

| Year. | Platinum. | Iridium. | Iridosmine-osmiridium. | Palladium. |
|---|---|---|---|---|
| 1914 | 3,430 | 64 | 195 | 2,635 |
| 1915 | 6,495 | 274 | 355 | 1,541 |
| 1916 | 24,518 | 370 | 315 | 2,885 |

Dealers and refiners reported sales in 1916 of 47,975 ounces of secondary platinum metals derived from refining scrap and sweeps. It must be realized that there is probably more or less duplication in these figures, and that the same metal may be handled as scrap several times in a year.

*Secondary platinum and allied metals sold in 1914–1916, in troy ounces.*

| Year. | Platinum. | Iridium. | Palladium. |
|---|---|---|---|
| 1914 | 40,698 | 129 | 1,500 |
| 1915 | 42,149 | 863 | 958 |
| 1916 | 45,156 | 1,535 | 1,284 |

[1] Commerce Repts., Apr. 30, 1917, p. 388.
[2] Jour. Ind. and Eng. Chemistry, vol. 9, No. 5, p. 444, May 1, 1917.

## WORLD'S PRODUCTION.

Statements of the world's production of platinum and allied metals are, at best, estimates made from the most reliable information obtainable. The statistics embodied in the table below are believed to be fairly accurate, though possibly the figures for Colombia are too high by several thousand ounces of crude metal not actually mined during 1916 but drawn out by the high prices from stocks held by natives and merchants.

*Estimated world's production of crude platinum, 1909–1916, in troy ounces.*

| Country. | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|
| Borneo and Sumatra. | 500 | 200 | ..... | ..... | 200 | (a) | (a) | (a) |
| Canada..... | 30 | 30 | 30 | 30 | 50 | 30 | 100 | 60 |
| Colombia..... | 6,000 | 10,000 | 12,000 | 12,000 | 15,000 | 17,500 | 18,000 | 25,000 |
| New South Wales and Tasmania..... | 440 | 332 | 470 | 778 | 1,500 | 1,248 | 303 | 222 |
| Russia..... | 264,000 | 275,000 | 300,000 | 300,000 | 250,000 | 241,200 | 124,000 | 63,900 |
| United States..... | 672 | 390 | 628 | 721 | 483 | 570 | 742 | 750 |
| | 271,642 | 285,952 | 313,128 | 313,529 | 267,233 | 260,548 | 143,145 | 89,932 |

a No basis for estimate.

## IMPORTS.

The imports of platinum and allied metals for consumption in 1916 were about 5,000 ounces below the imports in 1915, but the value of the diminished quantity increased nearly a million dollars, as is shown by the table below, compiled by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

*Platinum and allied metals imported for consumption in the United States, 1915–1916.*

| Metal. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity (troy ounces). | Value. | Quantity (troy ounces). | Value. |
| Platinum or crude platinum and unmanufactured products, ingots, bars, sheets, wires..... | 61,438 | $2,341,476 | 53,522 | $3,138,087 |
| Platinum, manufactured products, vases, retorts, etc.. | (a) | 73,799 | (a) | 21,872 |
| Iridium..... | 4,158 | 243,266 | 3,346 | 250,705 |
| Osmiridium..... | 130 | 5,737 | 414 | 17,241 |
| Osmium..... | 32 | 787 | ..... | ..... |
| Palladium..... | 3,020 | 103,623 | 6,513 | 282,910 |
| | 68,778 | 2,768,688 | 63,795 | 3,710,815 |

a Quantity not given.

*Platinum imported into the United States in 1915 and 1916.*

1915.

| | Unmanufactured. | | Ingots, bars, etc. | | Manufactured products, vases, etc. | Total value. |
|---|---|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. | | |
| France | 14,925 | $540,388 | 3,022 | $142,945 | $49,654 | $732,987 |
| Germany | 496 | 22,659 | 11 | 436 | 855 | 23,950 |
| Italy | ..... | ..... | ..... | ..... | 4,665 | 4,665 |
| Netherlands | ..... | ..... | 53 | 2,346 | 483 | 2,829 |
| Norway | 302 | 11,500 | ..... | ..... | ..... | 11,500 |
| Spain | 1 | 22 | ..... | ..... | ..... | 22 |
| England | 23,983 | 930,872 | 1,919 | 87,456 | 15,265 | 1,033,593 |
| Canada | 99 | 3,528 | 223 | 10,479 | 610 | 14,617 |
| Panama | 105 | 3,600 | ..... | ..... | ..... | 3,600 |
| Colombia | 15,818 | 564,967 | 480 | 19,278 | ..... | 584,245 |
| | 55,729 | 2,077,536 | 5,708 | 262,940 | 71,532 | [a]2,412,008 |

1916.

| | | | | | | |
|---|---|---|---|---|---|---|
| France | 26 | $1,841 | 2,006 | $111,068 | $16,471 | $129,380 |
| Chile | 686 | 55,412 | 15 | 800 | 269 | 56,481 |
| Netherlands | 21 | 1,604 | 106 | 4,941 | 1,818 | 8,363 |
| Norway | ..... | ..... | 120 | 6,280 | ..... | 6,280 |
| Spain | 7 | 311 | 46 | 2,065 | ..... | 2,376 |
| Peru | 7 | 475 | ..... | ..... | ..... | 475 |
| England | 15,256 | 733,198 | 9,475 | 469,815 | ..... | 1,203,013 |
| Canada | 42 | 2,599 | 464 | 36,164 | 332 | 39,095 |
| Panama | 92 | 6,560 | ..... | ..... | ..... | 6,560 |
| Mexico | 93 | 6,231 | 11 | 489 | 33 | 6,753 |
| Brazil | 221 | 19,797 | ..... | ..... | ..... | 19,797 |
| Colombia | 24,774 | 1,677,805 | ..... | ..... | ..... | 1,677,805 |
| Venezuela | 11 | 698 | ..... | ..... | ..... | 698 |
| Australia | ..... | ..... | 5 | 243 | ..... | 243 |
| | 41,236 | 2,506,531 | 12,248 | 631,865 | 18,923 | 3,157,319 |

[a] Does not include manufactured platinum upon which 50 per cent duty was imposed.

A comparison of the tables of imports by countries for 1915 and 1916 shows the decline of supplies received from Europe and the increase of crude platinum from Colombia. The unmanufactured platinum imported in 1916 from Chile and Mexico may have been from stocks and not from mines; that from Venezuela and Panama was possibly derived from Colombian mines. The table for 1916 shows, apparently, that some platinum was produced from the Brazilian deposits in that year—a production greatly to be desired in view of the decline of the output from Russia.

## MARKET AND PRICES.

### REFINED METALS.

The price of refined platinum in the New York market has been very erratic. Beginning at $90 a troy ounce in January, 1916, the price increased 75 cents an ounce to March, when it began to decline and reached $55, the lowest for the year, in August. Buying for the Christmas jewelry trade in September brought a strong reaction and quotations rose to an average of $101.25 for November, with a maximum of $105 at the end of the month. In December quotations were easier and the year closed with platinum at about $82 an ounce. The average monthly quotations are given below.

*Average prices of refined platinum per troy ounce in the New York market, 1912–1916.*[1]

| | | | |
|---|---|---|---|
| 1912 | $45.55 | 1916—Continued. | |
| 1913 | 44.88 | June | $78.13 |
| 1914 | 45.06 | July | 63.60 |
| 1915 | 49.63 | August | 62.56 |
| 1916: | | September | 84.25 |
| January | 90.05 | October | 89.75 |
| February | 90.00 | November | 101.25 |
| March | 90.75 | December | 86.87 |
| April | 83.10 | | |
| May | 80.50 | Average | 83.40 |

Refined palladium sold at $45 and $50 a troy ounce at the beginning of 1916, but prices advanced continuously to the end of October, when $80 was quoted. In November the market eased slightly and continued to decline to the end of the year, when the price was about $60 an ounce.

Refined iridium was apparently sold only by special bargaining, and no very definite information is available concerning its price. Apparently $85 was the nominal quotation in January, and $105 was quoted in December.

Prices reported to the United States Geological Survey by refiners of the platinum group of metals varied considerably in 1916. In the following table fairly average prices are given, and these are the prices that have been used by the Survey in all computations.

*Average price per troy ounce of refined metals of the platinum group, 1914–1916.*

| Metal. | 1914 | 1915 | 1916 |
|---|---|---|---|
| Platinum | $45 | $55 | $84 |
| Iridium | 65 | 83 | 94 |
| Iridosmine | 33 | 35 | 45 |
| Palladium | 44 | 56 | 67 |

No prices of osmium, rhodium, and ruthenium are available.

In England the platinum market is under Government control. Johnson, Matthey & Co., buying for the Government, paid at the first of the year at the rate of 190 shillings ($46.23) an ounce, but in August the buying price was advanced to 200 shillings ($48.67) an ounce and the selling price was fixed at 220 shillings ($53.53). On December 29, 1916, all the platinum metals were added to the list of absolute contraband by the British Government.[2]

An order by the Russian Government, which became effective February 1 (14), 1917, prohibits, among other things, the importation of drawn and spun platinum.

## CRUDE PLATINUM.

*United States.*—The miners of California and Oregon received from $29 to $38 an ounce for their crude platinum in 1915. In 1916 the price ranged from $43 to $76 and averaged about $45.50 an ounce, which is the price that has been used by the United States Geological Survey in all computations.

[1] Eng. and Min. Jour., vol. 103, pp. 4, 6, 1916.
[2] Commerce Repts., June 6, 1917.

*Colombia.*—The price of crude platinum in Colombia, as the Survey is informed, ranged in 1916 from $50 to $75 an ounce, the average price for the year being nearer the higher than the lower figure. Colombian crude platinum is estimated at 84 to 85 per cent fine.

*Russia.*—Early in 1916 the Russian Government issued an order prohibiting sales of crude platinum, but no bill against sales was passed and later in the year free sale of platinum was allowed. The market was confused by the contradictory action, but the selling price for the year was in general nearly double the average for 1915. Petrograde prices for 83 per cent platinum ranged from $61.14 an ounce in February to $77.42 an ounce in October, the last quotation available; the Ekaterinburg price ranged from $61.10 in January to $71.44 in October. Under date of November 11, 1916, the Russian correspondent of the Engineering and Mining Journal [1] stated that by Government order the production of platinum had been taken over by the state banks at a price of $70.56 an ounce, crude metal 83 per cent pure, and that private trading had stopped.

## OCCURRENCE.

With the exception of a relatively small quantity of platinum and allied metals obtained by electrolytic refiners of copper, nickel, and gold all the platinum in the world has been won from placer deposits. Eilers [2] some years ago made a study of the precious metal content of blister copper, but apparently did not attempt to locate the copper mines from which the ores were derived. The United States Geological Survey in 1915 sent inquiries to many of the large producers of copper in the Western States to ascertain which mines produced platiniferous ores, but the results were not complete. At many mines no assays had been made for platinum and at the few mines where such assays had been made the results were negative. This, however, is not to be wondered at, for Eilers [3] found that the blister copper sent to refiners contained small quantities of platinum, the highest content reported by him being 1.825 ounces per 100 tons of blister refined at the Omaha smelter.

The mother rocks of platinum are basic igneous rocks, peridotite, pyroxenite, and dunite. The peridotites and pyroxenites are dark-gray to black heavy rocks composed principally of black or dark-green iron-magnesium silicates, pyroxene, augite and hornblende, olivine, plagioclase feldspar, chromite, ilmenite, and magnetite. Dunites are composed principally of olivine with some chromite. There is every gradation between these types of rocks and the less basic rocks. A characteristic of the basic rocks is their tendency to alter to serpentine, a soft, greasy fibrous mineral of olive-green to black color that once seen is readily remembered. Attempts to trace platinum to its source have proved successful in Russia, Spain, and Canada, but no deposit of platinum in the mother rock has been found of commercial grade under normal conditions. It is possible, but does not seem probable, that bodies of platiniferous rock may be found in the United States rich enough in platinum to be worked under present conditions. It should be recalled, however, by all persons searching

[1] Eng. and Min. Jour., Jan. 6, 1917.
[2] Eilers, A., Notes on the occurrence of some of the rarer metals in blister copper: Am. Inst. Min. Eng. Trans., vol. 47, pp. 217-218, 1913.
[3] Op. cit., p. 217.

for platinum ores that the assay for platinum is difficult and apparently can not be successfully made by all commercial assayers. It is therefore recommended that samples of supposed platiniferous ores be sent only to the most reliable analysts of the country. The United States Geological Survey has received several reports of discoveries of rich platinum ore in which "the platinum could not be detected by the ordinary methods of assay." From all available information, such reports should be regarded with suspicion, for it is confidently believed that any platinum ore of commercial grade will yield to standard methods of analysis if made by competent and reliable analysts.

## NOTES ON THE PLATINUM DEPOSITS.

### UNITED STATES.

#### GENERAL STATEMENT.

In the United States the largest part of the output of crude placer platinum is won by dredges at the west base of the Sierra Nevada, which are working gravels derived from the famous Mother Lode. The greater production from this region than from northwestern California and southwestern Oregon and other places would appear to be due to the larger operations in this field rather than to the more widespread or richer distribution of platinum.

In view of the present situation of the United States with respect to platinum it may be well to mention the localities in the Western States in which basic igneous rocks are known to occur, particularly the areas containing chromiferous serpentine, from which the platinum appears to be derived. The United States Geological Survey has already planned a complete study of this western region in the hope that certain areas may be designated as worthy the careful attention of capital. The Government has not in contemplation at this time the purchase or operation of any platiniferous deposits. It is hoped, however, that the field work of Louis M. Prindle and James M. Hill, of the United States Geological Survey, who have undertaken this study, will be of value in guiding further private development and thus increasing the domestic production of this necessary metal in the western United States.

#### ALASKA.

Platinum was won in the Koyuk, Fairhaven, and Chistochina districts, Alaska, in 1916, and about 12 ounces was shipped to the United States. Its occurrence in the Territory was known, but no production of the metal was reported by mine operations prior to 1916.

Brooks [1] has published a short paper on the deposits of platinum in Alaska, from which the following summary is compiled:

Platinum and palladium have been recognized in the copper ores of the Goodro mine, Prince of Wales Island, which are in a heavy green dioritic rock containing bornite, chalcocite, and chalcopyrite. Peroditic rocks of the general platiniferous type occur in the southern part of Kenai Peninsula; they do not appear to have been examined for platinum.

[1] Brooks, A. H., Alaska's mineral supplies: U. S. Geol. Survey Bull. 666-P, 1917.

Placer platinum has been found in the Slate Creek basin, and osmiridium in the gravels of Miller Gulch, of the Chistochina district, in the Copper River basin. The beach placers at Lituya Bay carry small quantities of platinum, and it is reported, though not confirmed, that there is platinum in the beach placers of Yakutat Bay and on Kodiak Island.

The placer gravels of Colorado Creek, in Kenai Peninsula, and of Kahiltna River, in the Yentna district, carry platinum as well as gold. Samples of concentrates sent to the Survey from Boob Creek, a tributary of Mastodon Creek, in the Innoko district, contain platinum.

Placer miners on Dime Creek, in the Koyuk district, southeastern Seward Peninsula, obtained several ounces of platinum in 1916 in the ordinary gold operations, and it would appear from all available information that this occurrence may prove of considerable importance.

In the northeastern part of Seward Peninsula the gravels of Bear Creek, Fairhaven district, carry platinum.

In the field season of 1917, J. B. Mertie, jr., Theodore Chapin, G. L. Harrington, and A. G. Maddren, of the United States Geological Survey, will visit localities in Alaska in which platinum has been reported.

## CALIFORNIA.

Sales in 1916 of 690 ounces of crude platinum obtained from California placer mines were reported to the Survey. The largest production was made by the dredges in Butte, Yuba, Calaveras, and Stanislaus counties. As is well recognized, the gold and platinum in these placers were derived originally in large part from the Mother Lode country. Along this remarkable belt of gold veins there are numerous areas of serpentine, in which chromite has been found at many places and platinum at a few.

Samples of platinum-bearing ore from the La Plata mine, Liberty Hill district, Nevada County, have been received by the Survey. The ore is a greenish siliceous rock, in which pyrrhotite and chalcopyrite are present in conspicuous quantity. The ore body is reported to occur in gabbro, lying west of the main serpentine area and east of the slate in the west-central part of the Colfax quadrangle,[1] about 1½ miles west of Camel Hump, on the Dutch Flat and Lowell Hill road. Outcrops of serpentine rich in chromite and olivine are said to lie near the vein.

The Mother Lode region of California has been studied in considerable detail and the rock formations are mapped in the following folios published by the United States Geological Survey:

| | Folio. | | Folio. |
|---|---|---|---|
| Bidwell Bar | 43 | Placerville | 3 |
| Downieville | 37 | Jackson | 11 |
| Marysville | 17 | Big Trees | 51 |
| Smartsville | 18 | Sonora | 41 |
| Colfax | 66 | Mother Lode district | 63 |
| Sacramento | 5 | | |

[1] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), 1900.

The serpentine belt extends from central Plumas County south to Fresno County, but is not a continuous outcrop. The larger areas shown in the geologic folios mentioned above are located as follows:

*Plumas County.*—Near Whisky Diggings, Indian Hill, Goodyear Bar, Grizzly Hill, and Gravel Hill.
*Butte County.*—Near Big Bar, Brush Creek, and Clipper Mill.
*Yuba County.*—Near Nevada City and Sweet Ranch.
*Sierra County.*—Near Chips Flat.
*Nevada County.*—Near Washington.
*Placer County.*—Near Auburn, Towle, Sugarpine mill, and Bath.
*Eldorado County.*—Near Pilot Hill, Flagstaff Hill, and Mount Ararat.
*Amador County.*—Near Drytown and Mountain Springs.
*Calaveras County.*—Near Cottage Springs.
*Tuolumne County.*—Near Rawhide, Montezuma, and Jacksonville.
*Mariposa County.*—Near Benton mill and Mount Bullion.

In Fresno County there are large masses of chromiferous serpentine at Portersville and east of Piedra, on Kings River, but so far as known to the Survey no placer operations have been attempted in this region.

Lindgren [1] says of this belt:

> Platinum is of widespread occurrence in the Sierra Nevada. * * * It is derived from serpentine, peridotite, or gabbro * * *. It is safe to say that platinum is universally present in the gravels of the Sierra Nevada wherever these have been derived from the erosion of serpentine areas.

In northwestern California, particularly in the Klamath Mountains, platinum was won at several mines in 1916, the production from this region amounting to 127 ounces, largely from Trinity, Humboldt, and Siskiyou counties. Platinum is also known to occur in Del Norte County. The recently published geologic map of California [2] does not distinguish the serpentine areas, but from other sources it is known that there are considerable bodies of serpentine in the following general localities:

A large area in southeastern Siskiyou and northeastern Trinity counties, centered about Trinity Center, Minersville, Carrville, Dodge, and Dunsmuir.
Several small areas on Hayfork Creek of Trinity River, in central Trinity County, and a large tongue extending southeast from Loudon to Bully Choop in the eastern part of the county.
A large but little-known area in western Siskiyou and eastern Del Norte counties which extends north into Oregon.
A belt along the eastern and northern boundaries of Humboldt County concerning which there is little detailed geologic information.

The irregular mountain mass in southwestern California, in San Diego and Riverside counties, is made up largely of igneous rocks, which in some areas are very basic. Gold veins have been worked, and Calkins [3] has recently described the occurrence of nickeliferous pyrrhotite-chalcopyrite ore in amphibole-olivine gabbro in the Julian district, 60 miles north of San Diego, and has suggested the possibility of these ores carrying platinum. He states that the ores have apparently not been tested for platinum. It might be advisable to investigate such gravels of the streams in this region as are definitely known to have originated in areas of basic igneous rocks.

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[1] Lindgren, Waldemar, Tertiary gravels of the Sierra Nevada of California: U. S. Geol Survey Prof. Paper 73, p. 74, 1911.
[2] Smith, J. P., Geologic map of California, California State Min. Bureau, 1916.
[3] Calkins, F. C., An occurrence of nickel ore in San Diego, Cal.: U. S. Geol. Survey Bull. 640, pp. 77–82, 1916 (Bull. 640-D).

## NEVADA.

Reports in the mining journals indicate that the Boss and Oro Amigo mines, in the Goodsprings district, Clark County, have been actively worked during 1916 and that several shipments of platiniferous copper ore were made from the Boss mine. It is stated that a modified chlorination mill for the treatment of Boss ores was practically completed late in 1916.

Crampton [1] states that the primary mineralization at the Boss mine was greatest along easily replaced dolomitic limestone beds near some minor faults. The mineralization was followed by faulting. Downward enrichment, Crampton believes, has caused a segregation of the platinum and palladium in an intermediate zone lying below oxidized copper ore barren as to platinum metals and above a zone of chalcocite ore which is encountered at depth and which contains little platinum except as a thin marginal coating on the top of the body. Knopf,[2] in commenting on Crampton's paper, notes the insolubility of platinum in known reagents and suggests that in the primary ore of the Boss mine, which has not yet been developed, platinum and palladium will probably be found as a chemical compound which is easily susceptible to oxidation.

## OREGON.

The stream placer deposits of southwestern Oregon, in Josephine, Curry, and Coos counties, have long been known to carry platinum in certain placers. The beach placers in Coos and Curry counties have produced some platinum, as have also the placers of Illinois River, particularly those near Kerby and Waldo. Platinum has been reported from time to time in the Blue Mountains of eastern Oregon, but the first production from eastern Oregon worth noting was reported in 1916 by the Sumpter dredges. The total production of crude platinum reported by Oregon mines in 1916 was 20 ounces.

The geology of southwestern Oregon has been summarized by Diller,[3] from whose report and map the following outline of the occurrence of serpentine is abstracted.

In Josephine County a broad belt of serpentine extends from a point near Galice, on Rogue River, in a southerly direction and passes near Kerby and Waldo to and beyond the California line. A smaller tongue crosses Illinois River, near Gold Basin Butte, and trends north-northwest beyond Rogue River, crossing the river a few miles west of Galice. There is also a small serpentine body at Bolt Mountain near Wildeville.

In Jackson County only small serpentine areas have been mapped, the largest being east of Gold Hill and on Case Creek, southwest of Murphy.

In Curry County [4] there are small areas of serpentine near Langlois and Ophir, on the coast, and at Iron and Johnson mountains, on the southeastern county line. Little is known in detail of this distribution of serpentine in Coos County.

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[1] Crampton, F. A., Platinum at the Boss mine, Goodsprings, Nev.: Min. and Sci. Press, vol. 112, pp. 479-482, 1916.

[2] Knopf, Adolph, Platinum of the Boss mine: Min. and Sci. Press, vol. 112, p. 623, Apr. 29, 1916; A gold-platinum-palladium lode in southern Nevada: U. S. Geol. Survey Bull. 620, pp. 1-18, 1916.

[3] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 547, 1914.

[4] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Port Orford folio (No. 89), 1903.

In Douglas County [1] there are large masses of serpentine, one crossing Little River near Peel, 15 miles east of Roseburg, and another trending northeast and extending from a point near Riddles on Myrtle Creek to Brushy Butte. There are several smaller masses in the region between the two larger masses. There is also a considerable body of serpentine forming Sexton Mountain, northeast of Merlin and Hugo.

Several of the copper mines in the peridotite-serpentine area of Douglas County produce platiniferous ore.

In Grant and Baker counties of eastern Oregon serpentine, according to Lindgren,[2] "forms large areas in the vicinity of Robinsonville and Bonanza, in the eastern part of the Greenhorn Mountains, at Susanville, and in the Strawberry Range south of Prairie and Canyon. The serpentine is an altered form of gabbro, perhaps also peridotites." Pardee and Hewett [3] state that dikes of dunite, porphyry, and pyroxenite are widely distributed in the Sumpter region. Chromite and platinum have been reported in the placer gravels of various streams in the Blue Mountains and from the Spanish Gulch mining district, south of Dayville, in the extreme eastern part of Grant County.

Press reports [4] in June stated that a blind lead, opened by a deep tunnel at the Compton mines, Susanville, Grant County, carried 1.10 ounces of platinum and $4.40 gold a ton.

It has been reported [5] that platinum has been discovered in the black sands of Buck Gulch, near Sumpter, Baker County.

Late in 1916 T. W. Gruetter informed the Geological Survey that he was installing a custom plant for the recovery of platinum from concentrates at Kerby, Josephine County.

### UTAH.

Recent developments at the horseshoe bend of Green River, east of Vernal, Utah, indicate that the placer deposits may be worked. The gravels at this place carry some platinum and gold, though both metals are in very fine particles and are difficult to save. Platinum has been detected in the gravels of Colorado River near Hite, below the mouth of Green River. Several attempts to mine these deposits on a large scale have not proved profitable, doubtless owing in part to the great difficulty of obtaining supplies in this inaccessible place and in part to the difficulty of saving platinum so finely divided and in such small quantity.

### WASHINGTON.

In July, 1916, samples of placer concentrates were received by the Geological Survey from a deposit near Riverside, Okanogan County, Wash., which contain platinum in considerable proportion. Apparently the platinum comes from a broad belt of chromite-bearing serpentine that lies west of Okanogan River and extends from a point near Oroville, Wash., to and beyond the Canadian boundary. Plati-

[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Roseburg folio (No. 49), 1898.
[2] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, p. 589, 1901.
[3] Pardee, J. T., and Hewett, D. F., Geology and mineral resources of the Sumpter quadrangle, Oreg.: Oregon Bur. Mines and Geology, vol. 1, No. 6, p. 38, 1912.
[4] Eng. and Min. Jour., June 24, 1916.
[5] Min. and Eng. World, June 17, 1916.

num has also been found on South Fork of Lewis River, in Clarke County, southwestern Washington.

Russell[1] gives a generalized account of the areas of serpentine in the mountains of central Washington, particularly of a large body about Mount Stuart, in the Wenatchee Mountains, near Blewett, and of small masses near Darrington and Twisp and on Methow River.

### WYOMING.

The Rambler mine, near Holmes, Albany County, has been developed by the Platinum Mining & Milling Co. Shipments of platiniferous concentrates have been made to eastern refiners.

The Rambler mine has opened a dioritic dike, which is associated with peridotite. The ore bodies are in crushed altered diorite and contain copper and iron sulphides and sperrylite (platinum arsenide). Enrichment by downward-moving waters is shown. The dioritic ore body is evidently, according to Kemp,[2] an intrusive body in the granite gneiss country rock.

## FOREIGN.

### BORNEO.

Platinum is found with gold in the gravels of certain streams in southeastern Borneo, in the Tanath-Laut region. The streams rise in the Bobaris Mountains, which are formed of crystalline schists and gneiss that have been intruded by basic dikes ranging from chromite to olivine gabbro. These rocks have been altered to serpentine. In the gravels which are formed from these rocks olivine, chromite, and platinum are found with gold.

Analyses of 10 samples of platinum and 15 samples of native osmium-ruthenium alloys from the Borneo field have recently been published.[3]

### BRAZIL.

Platinum, with some iridium and iridosmine, has been known for many years in the region of Minas Geraes, central Brazil, and has been won in small quantities from the gold washings of the Rio de Velhas. Gold in alloy with silver and occasionally with platinum has been found in the Boa Esperança veins, at Gongo Sico in veins in syenitic granite, and in the itabirite of the Minas district. Little has been heard of late years of these deposits, and apparently no platinum or platinum metals are now produced from them.

### CANADA.

*British Columbia.*—No new developments were noted during the year in the Tulameen district. The production of the district is estimated as 60 ounces for 1916.

*Manitoba.*—Platinum is reported to occur in several mines and prospects in The Pas district, Manitoba.

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[1] Russell, I. C., A preliminary paper on the geology of the Cascade Mountains in northern Washington: U. S. Geol. Survey Twentieth Ann. Rept., pt. 2, pp. 109–111, 1900. See also Smith, G. O., U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (No. 106), 1904.

[2] Kemp, J. F., Platinum in the Rambler mine, Wyo.: U. S. Geol. Survey Mineral Resources, 1902, pp.: 244–250, 1904.

[3] Mus. Acad. sci. Petrograd Trav., vol. 6, pp. 49–95, 1915; Chem. Abstracts, vol. 10, p. 440, 1916.

*Ontario.*—Early in 1916 the construction of a nickel refinery at Port Colburn by the International Nickel Co. was begun. This plant will handle part of the output of copper-nickel matte from the Sudbury mines, from which platinum and palladium are obtained.

## COLOMBIA.

The United States vice consul at Cartagena states [1] that 15,790 troy ounces of crude platinum was invoiced at that port for shipment to the United States in 1916. Additional advices received by the Geological Survey indicate that native miners, stimulated by the high prices received for crude platinum, made a much greater recovery than ever before in the history of the country. The litigation between British and American interests in the Condoto region was adjusted late in 1916, and a holding company known as the South American Gold & Platinum Co. was organized to take over the interests of the two. It is reported that an American-built dredge has already been ordered, which will operate on the Condoto.

Interesting statistics of production of gold and platinum from the Choco have been published by Gutiérrez,[2] as well as information concerning the platiniferous deposits. Gutiérrez points out in particular the lack of adequate capital in the development of the properties and indicates the reasons for the unreliable production by native labor. A valuable appendix to this work gives a list of mining properties for which title has been obtained, showing their location, character (lode or placer), and ownership. Other lists show the condition of taxes on the properties.

Some details concerning the platiniferous deposits were published in the report for 1915 of this series,[3] and no new information concerning them is available.

Under the heading "New Colombian mining regulations," [4] the United States Department of Commerce [1] gives a summary of the revised mining laws of Colombia. The concession is limited to 3.86 square miles and has a life of 25 years. The concessionaire must, within 18 months of the approval of the concession, file with the minister of public works (1) the precise location of his mine, (2) plans of the workings, and (3) samples of the mineral. Active mining must be begun within two years. The Government claims the right to 15 per cent of the gross receipts of the work and authorizes the concessionaire to erect all buildings, roads, light railways, cable, and telegraph and telephone lines, etc. Concessions can apparently be made only to Colombians, for the decree states that transfers of concessions to aliens can be made upon permission of the Colombian Government.

## NEW SOUTH WALES.

Platinum occurs with gold, tin, and monazite in beach sands on the northeastern coast of New South Wales, at the mouths of Clarence and Richmond rivers. Apparently the production from this source has been small.

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[1] Commerce Reports, No. 24, p. 370, Jan. 29, 1917.
[2] Gutiérrez, J. M., Report on the exploitation of platinum in El Choco: Ministerio de Relac. Exter. [Colombia] Bol., vol. 7, No. 8-10, pp. 339-389, August-December, 1914.
[3] Hill, J. M., Platinum and allied metals: U. S. Geol Survey Mineral Resources, 1915, pt. 1, pp. 145-146, 1916.
[4] Commerce Repts., June 8, 1916.

Platinum has also been found in some masses of ironstone at Darling Creek and Mulga Springs, near Broken Hill. The mode of occurrence has not yet been determined, though it is thought that the metal is associated with arsenic in the form of sperrylite.[1]

Most of the platinum produced in New South Wales has come from alluvial washings at Fifield and Platina, in the central part of the Province. The pay gravels,[2] 6 to 13 inches thick, rest on shales and sandstones of Silurian and Devonian age, which are cut by diorite. The producing area is about 1 mile long by 60 to 150 feet wide. It has an overburden of 10 to 70 feet. Water is scarce in the district and the gravels can be worked only part of the year. The crude platinum is said to be 75 per cent platinum metals and an analysis shows the following:

*Analysis of crude platinum, Fifield, New South Wales.*

| | | | |
|---|---|---|---|
| Platinum | 75.90 | Copper | .41 |
| Iridium | 1.30 | Gold | None. |
| Rhodium | 1.30 | Lead | Trace. |
| Palladium | Trace. | Silica | 1.12 |
| Osmiridium | 9.30 | | |
| Iron | 10.15 | | 99.48 |

Of late years the production from this district has been greatly diminished and it is probable that, unless the greatly enhanced price in 1916 has led to the working of gravels at lower grade, the production will be very small. A report of the New South Wales Geological Survey for 1915[3] estimates that at present 200 acres of shallow platiniferous ground could be worked if sufficient water were available. The same report gives the total production of platinum from New South Wales, since the first exploitation of the Fifield gravels in 1894 and including the output of 56 ounces in 1915, as 13,732 troy ounces, valued at £34,750 ($168,873.50).

### QUEENSLAND.

Small quantities of platinum are known to occur with tinstone, monazite, and gold in the beach sands at the southeastern border of Queensland. So far as can be learned, little platinum has been saved from these deposits, owing not only to their low tenor but also to the great difficulty of separating the small flakes of this metal from the great quantity of heavy concentrates obtained by washing these gravels.

### RUSSIA.

The British consul at Ekaterinburg reported in October[4] that the estimated production of platinum in Russia during 1916 was between 100 poods (52,664.51 ounces) and 120 poods (63,197.41 ounces). This decrease of 33 per cent is attributed to the scarcity of laborers and the difficulty of obtaining parts for the dredges.

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[1] Mingay, J. C. H., Chemical notes on lode material from Broken Hill containing copper, nickel, platinum, and platinoid metals: New South Wales Geol. Survey Rec., vol. 8, pt. 4, pp. 287-292, 1909.

[2] Jaquel, J. B., Report on the occurrence of platinum at Fifield: New South Wales Dept. Mines and Agr. Ann. Rept. for 1895, pp. 181-183, 1896.

[3] New South Wales Dept. Mines and Agr. Ann. Rept. for 1915, p. 59, 1916.

[4] British (Govt.) Board of Trade Jour., Oct. 26, 1916; Commerce Repts., Nov. 18, 1916; Eng. and Min. Jour., vol. 102, p. 1113, 1916.

An interesting summary of the Russian platinum industry, prepared as a "Special supplement to the budget estimate of the Mining Department (of Russia) for 1916," was published at Petrograd in 1915. This volume covers the mineral resources of the Russian Empire. In the chapter on the platinum industry, the report gives a large amount of historical and statistical data with relation to the production, exportation, and use of the metal. An interesting table (No. 28 on p. 78) shows the relation of production to exports and price. The total production to 1914, inclusive, from placers is given as 6,496 poods or 3,421,087 troy ounces. It is clearly brought out that the Russian use of platinum for the period 1889–1913 was approximately 1.8 per cent of the production. The exports are shown to have been distributed as follows: 70 per cent to France, 29 per cent to Germany, and about three-fourths of 1 per cent to Great Britain. The fluctuation in prices of crude platinum is discussed in some detail. A brief discussion of the methods of mining and some details of the number of producing mines in the various districts are given at the conclusion of this chapter of the report.

Of more interest from the point of view of the geologist is a report by Duparc,[1] in which the author reviews briefly the geology of the platiniferous deposits of the Urals. After describing these deposits Deparc devotes considerable space to explaining the occurrence of platinum in the primary rocks, distinguishing two types of the Uralian deposits, the dunitic and the pyroxenitic primary platiniferous rocks. Neither of these are rich enough in platinum to be workable. The hypothesis is stated that the platinum of these deposits is purely magmatic and that the metal is a final product of the differentiation of a basis magma, which may be more or less complete and of which he says "the native platinum is then like the final product of an incomplete cupulation, the slag resulting from the cupulation represented by the eruptive rock." The very general concentric banding of the deposits is discussed, from the relatively acidic feldspathic rocks at the outer edge, grading into more basic rocks to pyroxenes in the intermediate stage, and finally to the dunite center composed of olivine and chromite, which is not always developed. Duparc points out that the richness of the primary deposits depends on the size of the body and on the degree of differentiation. As platinum is obtained only from placer washings, the richness of the gravels is of importance, and, according to Duparc, is directly proportionate to the size of the dunite deposits and to the degree to which these deposits have been eroded. He discusses at some length the variations in composition between the platinum from different sources and brings out the fact that platinum ore from pyroxenitic centers is generally richer in platinum, poorer in osmium, relatively lower in iron, and richer in palladium than the platinum ore from dunite centers. Duparc emphasizes the difficulties of prospecting for new platineferous deposits and the meager results obtained so far by the numerous prospecting parties. He discusses in some detail the various mechanical devices which have been used in Russia for the recovery of platinum and describes in particular the latest dredge which has 7½ cubic feet close-connected buckets, is electrically driven, and has a rather unique arrangement

[1] Duparc, L., Le platine et les gites platinifères de l'Oural: Soc. ing. civils France Mém. (Bull. janvier-mars), 1916.

of sluices by which any one box may be removed for clean-up without stopping the operation of the dredge. Platinum deposits in all parts of the world are briefly discussed, with some notes on their relative importance as possible producers and their analogies to the classic Russian types.

Duparc closes his paper with a brief review of the production and uses of platinum and makes the statement concerning the Ural deposits that "the reserves appear to be sufficient for about 12 years, if no new dredges are built, and if the methods of working remain approximately as to-day." He points out the prime necessity of platinum in various industries, and concludes that "it will be necessary at once to discover new deposits that will be able to make up for the lessening production of the Urals."

## SPAIN.

Notes concerning the discovery of platinum in the Sierra de Ronda, in southern Spain, were given in the report on platinum for 1915. Detailed descriptions of these deposits by the discoverer, Don Domingo de Orueta, have been published.[1] In some respects the Spanish deposits resemble those of Russia, but Duparc and Grossett [2] have emphasized the distinctions between the classic dunitic and pyroxenitic Uralian primary deposits and the peridotitic type found in the Sierra de Ronda.

The Russian primary deposits are essentially of magmatic origin and show a gradation from feldspathic rocks to the very basic chromite-olivine rock dunite, whereas the Spanish primary deposits are in rocks composed of rhombic pyroxene characterized by spinel with some gradations into dunitic phases.

The secondary (placer) deposits are also very different. The Russian platiniferous gravels are in large part old and have been reworked by the present streams. The topography is subdued, and the region is, in fact, nearly a peneplain. The Spanish platiniferous gravels, on the contrary, occupy steep-walled, young valleys. In the Russian deposits practically all the platinum is found in the bedrock gravels, which are distinct from the two overlying beds, but in the Spanish deposits there is a gradation from coarser to finer gravels from surface to bedrock, and, while there is slightly more platinum near bedrock than in the upper part of the gravels, there is no sharply marked pay bed.

Details concerning the most recent work on these deposits [3] indicate that some areas will be found of workable grade.

## TASMANIA.

The osmiridium fields, 20 miles west of Waratah on Nineteen Mile Creek, a tributary of Savage River, were worked in 1916 and produced 222 ounces of crude metal. No information is available to indicate whether the primary deposits described by Twelvetrees [4] have been exploited.

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[1] Revista Min., Nov. 8, 1915, No. 2519: Comp. Rend. January, 1916.
[2] Duparc, Luis, and Grossett, Augustine, Étude comparée des gîtes platinifères de la Sierra de Ronda et de l'Oural: Soc. phys. et hist. nat. Genève Mém., vol. 38, fasc. 5, 1916.
[3] Commerce Repts., May 5, 1917, pp. 476–477.
[4] Twelvetrees, W. H., The Bald Hill osmiridium field: Tasmania Dept. Mines Geol. Survey Bull. 17, 1914.

## METALLURGY.

Some details of the metallurgy of the platinum group of metals were given in the report on platinum for 1915. Little detailed information is at hand concerning the recent experiments on Boss ores, but it is understood that a form of chlorination treatment is to be used. A small experimental plant has already been built at the mine, near Goodsprings, Nev. The results of this experiment will be watched with considerable interest.

Of equal importance to the American industry is the working out of a method for the commercial recovery of platinum from the black sands obtained at many placer deposits in California and Oregon. In the report for 1915 the suggestion was made that small custom mills for the treatment of black sands, conveniently located throughout the platiniferous placer region, might successfully solve this problem.

The Geological Survey has been informed that a custom mill has been built at Kerby, Oreg., for the treatment of black sands. It is understood that the first installation, by T. W. Gruetter is small. The exact process to be used is not divulged, though it may follow the plans outlined by Gruetter in the technical press.[1] The success of this installation will mean much to southwestern Oregon and northwestern California. For, if it is demonstrated that placer concentrates can be successfully and profitably handled by custom plants, there would seem to be little question of similar installation at various places where platinum is known to occur.

Albert H. Sherwood, of Oroville, Cal., has patented [2] a process for recovering fine gold and platinum in which the sands, after a preliminary wash with 15–25 per cent sulphuric acid, are subjected to an amalgamation process using copper amalgam and copper sulphate. The method described [3] uses three or four stages and a variety of chemicals and apparatus. It is not known whether any plant using this plan is in operation.

The Platinum Metals Co., of Philadelphia, is putting on the market a product called "amagnite," which, when added to mercury in ordinary amalgamation, is claimed to aid the amalgamation of rusty and greasy gold and to hold platinum. The company is erecting an experimental plant at Philadelphia, which will be ready for operation by July, 1917.

## USES.

Little can be added to the summary of uses of platinum given in the report for 1915.[4] A few alloys, which may replace platinum chemical ware, have been patented, among which "rhotanim," made by the Industrial Research Co., of Cleveland, Ohio, has been widely advertised. Another alloy, "palau," containing palladium and gold, made by the Pacific Platinum Works, is said by the Bureau of Standards, Department of Commerce, to have considerable promise for certain chemical uses. Several other palladium-gold alloys for

[1] Min. and Sci. Press, vol. 111, pp. 698–699, 1915; idem, vol. 113, pp. 20–21, 1916.
[2] U. S. patent 1192945, dated Aug. 1, 1916.
[3] Met. and Chem. Eng., p. 603, Nov. 15, 1916.
[4] Hill, J. M., Platinum and allied metals: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, pp. 148–151, 1916.

chemical ware have been put on the market. Greenwood [1] states that under certain conditions gold dishes can replace platinum dishes for hydrofluoric-acid treatments in the chemical laboratory. Nickel dishes have also been found useful in the laboratory.

Silver palladium alloys for contact and spark devices of internal-combustion engines have been brought out during 1916, and white alloys of gold with platinum and palladium for use in the jewelry trade have again made their appearance.

An interesting article by Hoke,[2] relative to the present American practice of melting and welding platinum, gives much information concerning the technic of handling the oxygen-gas blowpipe in melting platinum. Another paper by the same author [3] gives much additional information of value to the manufacturing jeweler.

## HINTS FOR PROSPECTORS.

Platinum is not known in all countries in the world, but that all the deposits of this valuable metal are known is highly improbable. In fact, platiniferous deposits in southern Spain have been discovered recently by a geologist working on the assumption that the place to look for platinum is in areas of basic igneous rocks similar to the typical Russian rocks. Systematic search, based on similar assumption, in all countries may lead to the discovery of new deposits of platiniferous gravels of economic importance, but a note of warning should be sounded. In Russia such systematic work has been in progress for many years and although new deposits have been found they are not so numerous nor so rich as the hope of the explorers anticipated.

Platinum, both as the native metal and in the form of sperrylite (platinum arsenide) has been found in basic igneous rocks in several places in the world but not in commercial quantities. The search for the source of platinum in rocks is therefore not likely to be of particular value in obtaining an immediate supply of the metal from lode deposits; it may, however, develop near-by gravel deposits. As already stated, it is confidently believed that any platiniferous ores of commercial grade will yield to the regular analytical treatment in the hands of competent and reliable assayers.

The placer deposits containing platinum are all, so far as known, in the vicinity of areas of basic igneous rocks, and it would seem that in any search for new deposits of platiniferous gravels the first step is the search for outcrops of peridotite, pyroxenite, dunite, and serpentine. When areas of these rocks have been found, the gravels of the streams rising in them should be washed to ascertain if platinum is present. The heavy concentrates found in gravels carrying platinum are usually rich in chromite and olivine. The character of the rock particles often gives a clue to the source from which the gravels were derived.

Crude platinum, as it occurs in placer concentrates, is ordinarily a silvery white metal which could be confused only with silver and possibly pieces of iron or steel. It can be distinguished from both of

[1] Greenwood, H. P., Platinum versus gold dishes: Eng. and Min. Jour., vol. 101, p. 780, April 29, 1916.
[2] Hoke, C. M., The melting of platinum: Metal Industry, vol. 14, pp. 375-377, 470-472, 1916.
[3] Hoke, C. M., Fluxes in the jewelry factory: Idem pp. 191-193.

these metals, as they are soluble in dilute nitric acids; crude platinum can be dissolved only in concentrated aqua regia, a mixture of 3 parts of hydrochloric (muriatic) acid and 1 part of nitric acid.

In some placer deposits the grains of platinum are coated with a dark film and somewhat resemble the grains of the dark minerals chromite, magnetite, or ilmenite, from which they are separated by careful panning, as the specific gravity of platinum is greater than that of any of those minerals.

Platinum will not amalgamate with quicksilver alone, but will amalgamate if sodium is added. In ordinary quicksilver amalgamation the flakes of platinum float on the surface and can be removed. If sodium amalgam is used, the platinum may be separated from gold by agitating the amalgam with water until all the sodium is used up to form sodium hydroxide; then the platinum will come out on the surface of the amalgam, provided, of course, the amalgam is sufficiently liquid.

Platinum has a hardness of 4 to 5, and can be scratched with a knife. It is so malleable that it can be pounded without heating into very thin sheets. It is practically infusible; the grains can not be melted together, as particles of gold can.

A relatively simple chemical test can be made to determine the platinum. The metallic particles are dissolved by boiling in concentrated aqua regia and the resulting solution is allowed to remain on the stove till dry. The residue is dissolved again in hydrochloric acid and evaporated by boiling till the solution is thick but not quite dry. This mass is dissolved in distilled water and a few drops of sulphuric acid and of potassium iodide solution are added, which, in the presence of platinum, causes the solution to turn a very characteristic wine-red, if much of the metal is present, or to a reddish pink in the presence of small quantities of platinum.

The test outlined above is fairly delicate, but it can not be used to detect traces of platinum in the presence of large quantities of iron or other elements.

A second test may be applied to the aqua regia solution after the resolution in hydrochloric acid outlined above. In this test potassium chloride (KCl) is added to the solution, which precipitates yellow crystals of potassium platinic chloride ($K_2PCl_6$), if platinum is present.

A third test may be applied. Add ammonium chloride ($NH_4Cl$) to the aqua regia solution, which will precipitate yellow crystals of ammonium platinic chloride, if platinum is present.

The precipitates from tests 2 and 3 are both insoluble in alcohol but are soluble in water and may be reduced to platinum sponge by heating.

All these tests are comparatively simple and positive when made on single grains, but they can not be relied upon when various other elements are present in the material tested. It is, therefore, recommended that their use be restricted to grains of a single mineral picked from the concentrates obtained by panning a sample of either rock or gravel.

## FUTURE SOURCES.

As already indicated the world's supply of platinum requires careful thought and immediate attention. Platinum metals are practically indispensable to the chemical industry, are of great use in the electric industry, and are more or less essential in many minor industries. Manufacturing jewelers contend that no substitutes can replace platinum in their products, but, realizing the industrial need for this metal, they have agreed to restrict its use. The chemists, on the other hand, maintain that a metal of prime industrial use should not be diverted at the whim of fashion and that laws should be passed in all countries prohibiting this use of a metal whose future supply is so problematic.

On the authority of Duparc, the known Russian fields at the present rate of output can last only 12 years, and Russia produces 95 per cent of the world's output. The Australian Provinces, Tasmania, New South Wales, and New Zealand, have made small additions to the world's supply, but these fields as now known are not capable of supplying a hundredth part of the world's demands, and some of them are reported to be nearly exhausted. Borneo's fields have been little worked but seem to be of small area. The small annual output from North America appears to be capable of some increase but does not hold much hope for the future. The Spanish deposits give some promise but are apparently not large. South America, especially Colombia, possesses a considerable reserve, and more scientific working of the deposits will unquestionably help the situation. The search for new platiniferous fields in the Urals has not yet been highly successful. Little, however, is known of the possibilities of the Siberian placer fields.

The question of the future supply of platinum for the United States resolves itself then into three problems—first, an inventory of our present supply, particularly the unmanufactured platinum metals; second, the systematic search for new sources of supply; and third, the scientific development of these deposits to assure the maximum yield from their operation. The first two of these problems are now being attacked by the United States Geological Survey, and it is hoped that the technologic question may be in part answered by the investigations already started under Government and private auspices.

# CHROMITE.

By J. S. DILLER.

## INTRODUCTION.[1]

The great increase in the domestic production as well as in the importation of chromite[2] in 1916, coupled with the prompt utilization of the chrome ore thus made available, testifies to an especially prosperous condition of the domestic chrome industry.

The quantity of chromite produced and sold in the United States in 1916 was more than 14 times as much as was produced and sold in 1915. After the declaration of war abroad and the issue of embargoes on the shipment of chromite the great advance in cost and the uncertainty of ocean traffic profoundly disturbed for a time the importation of chromite and consequently increased the demand for the domestic product. The impetus was particularly felt in California, the only State producing a considerable quantity of chromite within the last few years.

The epoch of embargoes has passed only recently (May, 1917), and some of the British steamers that carried the imported chrome ore from South Africa and New Caledonia to the United States have been requisitioned for war service. The consequence will be to reduce imports and to increase the demand for domestic ore.

In January, 1916, the Southern Pacific Co. reduced its freight rate on chromite from points in California to Chicago to 50 cents and to Pittsburgh to 55 cents a hundred pounds in carload lots. The Santa Fe and the Western Pacific railroads made a corresponding reduction and thus enabled the California producer of chromite to reach the eastern market. Serpentine areas were prospected everywhere and the number of active quarries increased from a few to several hundred. The surface ore bodies were removed almost wholly by open-pit mining. Production in California increased very rapidly, and a number of large eastern users of chromite established agents in California to purchase ore.

Chromite is one of the primary minerals in deep-seated igneous rocks rich in iron and magnesia, such as peridotite and pyroxenite. The associated minerals, olivine and pyroxene, are generally altered to serpentine, so that serpentine has come to be the home of bodies of chromic iron ore. The chromic iron ore liberated during rock weathering and decay is concentrated upon the earth's surface. Scattered boulders of chromite on the surface of serpentine are not generally a reliable indication that a body of chromite will be found just beneath the surface.

[1] The numerous producers and brokers of chromite and the California State Mining Bureau have cooperated with the United States Geological Survey in obtaining the data for this report, and for this service the Survey thanks them. Special service has been rendered by two mining engineers of San Francisco, Messrs. Samuel H. Dolbear and J. R. Van Fleet, for which they are given credit in the report.

[2] "Chromite," "chromic iron ore," and "chrome ore" are used synonymously in this paper.

The chromite properties are handled in various ways. Some properties, including all mineral rights, are purchased outright before the chromite is removed, the price depending on the estimated value of the ore supposed to be available. The more popular and equitable plan is to lease the property on a royalty basis. The owners of the claims generally are prospectors and miners with small holdings, and the lessor is in most cases employed by the lessee, thus giving a special inducement to the lessor to discover and remove the greatest amount of ore. This plan appears to work satisfactorily at a number of points in the Sierra Nevada and the coast range. The royalty paid depends on the quality of the ore and its accessibility. Royalties ranged from 50 cents to $7.50 a ton, and at one place were 10 per cent of the value of the sales.

In development a road system is usually begun about the base on the gentler slope of a mountain of serpentine. The lower bodies of chrome ore are mined first. Then the next higher bodies are removed and sledded down to the wagon road, and so on to the top of the mountain. The wagon road is made only to deposits that justify road construction, and much of the work is done by the men who own the claims. There are disappointments and surprises. Many of the ore bodies prove to be smaller than expected, yielding only from 2 to 50 tons of ore, but of these some are found upon closer examination to connect by leaders to other deposits near by and thus reward further prospecting.

## COMPOSITION OF CHROMIC IRON ORE ON THE PACIFIC COAST.

None of the chromic iron ore mined on the Pacific coast has been concentrated before marketing otherwise than by rough sorting, and yet the grade of a large part of the ore suggests room for improvement in that direction, which could be effected to a large extent by more careful selection. Harold French[1] has recently given an account of the manufacture of chromates from chromite by the Sawyer Tanning Co., at Napa, Cal., and calls attention to the need of sorting the ore. Ores containing less than 50 per cent of $Cr_2O_3$, however suitable for the manufacture of ferrochrome and chrome bricks, are not desired by the industrial chemist. Complaints have been made that the general average of shipments is too low for best results. The Sawyer Tanning Co., in sorting ore for the manufacture of chromate of soda, has made three grades. The best grade[1] is said to be fine grained and brittle, resembling anthracite coal, and contains from 50 to 55 per cent of chromic oxide. The middle grade, like most of the chromite ore mined in California, resembles dull graphite, and averages 44 per cent of $Cr_2O_3$. The third grade, which assays only 35 per cent of $Cr_2O_3$, has a rusty ocherous color. In the application of this visual selection care must be taken to exclude strongly magnetic ore, for in some localities beautifully lustrous chrome ore may contain only 30 per cent of $Cr_2O_3$, the luster being caused by splendent magnetite.

The Sawyer Tanning Co., of Napa, Cal., in its recently established plant manufactures some of the chromium compounds largely used in the process of chrome tanning, a process that imparts to leather the quality of resisting heat and acids. For this process a reliable

[1] Min. and Sci. Press, Dec. 9, 1916, p. 845.

supply of high-grade chromite is necessary, and notwithstanding the average low grade of the ore, it is hoped that the grade may be improved, at least in certain localities, by concentration at the mines.

*Analyses of chromic iron ore from California and Oregon.*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| $Cr_2O_3$ | 34.25 | 42.20 | 51.61 | 51.74–57.18 | 52.68 |
| $SiO_2$ | 2.10 | 5.48 | 1.40 | 1.80–8.40 | 3.40 |
| $Al_2O_3$ | 25.36 | 13.60 | 14.62 | ..... | 11.40 |
| MgO | 19.07 | 14.88 | 13.06 | .51–4.09 | 16.23 |
| FeO | 17.07 | 23.84 | 18.09 | ..... | 11.77 |
| $Fe_2O_3$ | 1.77 | ..... | .50 | ..... | 3.52 |
| CaO | ..... | ..... | .24 | ..... | ..... |
| MnO | ..... | ..... | ..... | ..... | .15 |
| Ignition loss | .345 | ..... | .40 | ..... | .94 |

1. Sonoma County, Cal., analysis by Mutual Chemical Co. of America.
2. California. H. Ries, analyst, Economic Geology, 4th ed., p. 790.
3. Glenn County, Cal. Analysis by Mutual Chemical Co. of America for W. R. Chesley.
4. Riddle, Oreg. Analysis by Falkenburg & Co.
5. San Luis Obispo County, Cal., South Fork of Chorro Creek. H. Pemberton, analyst.

The following are the results of an examination by Chase Palmer, of the United States Geological Survey, of a sample of chromite from Wyoming:

*Composition of chromic iron ore from Wyoming.*

| | |
|---|---|
| $SiO_2$ | 7.21 |
| $Al_2O_3$ ($Fe_2O_3$) | 33.14 |
| $Cr_2O_3$ | 44.24 |

## PRODUCTION.

The greatly increased trade in steel and the consequently larger demand for ferrochrome have stimulated the search for chromite in the United States, as is shown by the fourteenfold increase in production in 1916 as compared with 1915. There were four producing States in 1916. On the Atlantic coast and in Wyoming there was only a small production, but in the Pacific Coast States, especially California, the advance in the output has been remarkable. Maryland and Wyoming had one producer in each State. Oregon, with about half a dozen producers in three counties, had a production which, combined with that of Maryland and Wyoming, amounted to 3,277 tons, valued at $43,306; California had a large number of producers in 22 counties and a total production of 43,758 tons, valued at $682,937. As heretofore, Shasta County had the largest output. The total yield for the United States was 47,035 long tons, valued at $726,243.

*Chromite produced and sold in the United States, 1913–1916, in long tons.*

| | | | |
|---|---|---|---|
| 1913 | 255 | 1915 | 3,281 |
| 1914 | 591 | 1916 | [1] 47,035 |

## PRICES.

The price of chromite in California on the basis of a content of 40 per cent of chromic oxide ranged in 1916 from $14 a ton f. o. b.

[1] The preliminary estimate was 35,000 long tons, but later information has shown that the total quantity sold was much larger. Although in summarizing reports from buyers and sellers as well as from producers and consumers it is difficult to avoid duplication, it is believed these figures are a close approximation of the ore sold. A considerable quantity of ore mined but not sold is not included in this estimate.

at points of shipment early in the season to $20 toward the end of the year. To this must be added for the eastern buyer a freight rate for carload lots ranging from $10 a ton to Chicago to nearly $15 a ton to the eastern seaboard and making the California 40 per cent ore cost on the eastern seaboard from $29 to $35 a ton. A premium of 50 cents a unit for chromium oxide is usually allowed and a penalty of 50 cents a unit is exacted for chromium oxide under 40 per cent and silica over 6 per cent. At the Atlantic seaboard the ore from the Pacific coast meets the imported ore, which is sold on the basis of a content of 50 per cent of chromic oxide. Prices of imported high-grade ore are reported as ranging in 1916 from $35 to $45 a ton f. o. b. eastern seaports. Low-grade Canadian ore containing 30 to 40 per cent chromic oxide sold for $25 to $30 a ton f. o. b. at the same points. Twenty-five per cent ore sold as low as $18 a ton.

## IMPORTS.

Embargoes were placed on the shipment of chrome ore from some of the principal sources, and it was feared that the supply for the United States would be cut off, but after the producers received a guaranty that the ore would not be reshipped to enemy belligerents the imports, as shown in the following table, greatly increased, compared with 1914, especially those from Rhodesia, New Caledonia, and Canada, though imports from Greece have declined slightly and those from Turkey have entirely ceased.

*Chromic iron ore imported into the United States, 1913–1916, in long tons.*[a]

| | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|
| Cuba | | | | 34 |
| Canada | | 533 | 10,087 | 12,220 |
| England | | 58 | 2 | 5 |
| Greece | 4,600 | 8,155 | 4,305 | 7,900 |
| Japan | 79 | | | |
| French Oceania | 21,850 | 30,860 | 28,031 | [b] 30,950 |
| Australia | | | | [b] 2,986 |
| British South Africa | | | 22,800 | [c] 23,000 |
| Portuguese Africa | 30,001 | 23,200 | 11,230 | [c] 38,850 |
| Turkey in Asia | 8,650 | 11,880 | | |
| | 65,180 | 74,686 | 76,455 | 115,945 |

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, U. S. Dept. Commerce.
[b] E. J. Lavino & Co., importers, credit New Caledonia with all ore listed under French Oceania and Australia, amounting to 33,936 long tons.
[c] E. J. Lavino & Co., importers, credit Rhodesia with all ore listed under British South Africa and Portuguese Africa, amounting to 61,850 long tons.

*Chromium compounds imported for consumption, 1915–16.*[a]

| | 1915 | | | 1916 | | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Price per unit. | Quantity. | Value. | Price per unit. |
| Chromic iron ore.....long tons.. | 76,455 | $780,061 | $10.20 | 115,945 | $1,548,402 | $13.35 |
| Chromic acid.....pounds.. | 3,571 | 755 | .211 | | | |
| Chromate and bichromate of potash.do.... | 32,942 | 2,902 | .088 | 459 | 75 | .16 |
| Chrome or chromium and ferrochrome or ferrochromium.....long tons.. | 32 | 1,662 | 51.94 | 10 | 1,998 | 199.80 |
| Chromate and bicromate of soda.pounds.. | | | | 6,154 | 3,630 | .59 |

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, U. S. Dept. Commerce.

## CHROME ORE IN THE UNITED STATES.

### OREGON.

The presence of chromite in the serpentine of southwestern and eastern Oregon has long been known, and many of the areas of serpentine in those regions have been mapped by the United States Geological Survey.[1] From the disintegration and erosion of these serpentine masses the grains and boulders of chromite accumulate in the surface soil and concentrate in the black sands along the streams and the beach.

The United States Geological Survey,[2] in connection with the Lewis and Clark Exposition at Portland, Oreg., in 1905, carried out a series of experiments with various standard concentrating machinery upon these black sands. These experiments were directed chiefly to the winning of gold and platinum, but they served also to emphasize the fact that the black sands of southwestern Oregon and northwestern California contain a considerable percentage of chromite and to suggest a placer method of winning it.

The stream wash of chromiferous serpentine areas other than the black sands also contains a notable amount of chromite. It appears probable that in some places, at least, the chromite is sufficiently abundant to warrant the employment of one of the standard concentrating tables, and then, by means of a magnetic separator, to remove the magnetite. The same plant could be used in concentrating poor ores.

In Oregon chromic iron ore has been found in many counties, but it is produced in only three, Grant, Douglas, and Josephine.

*Grant County.*—Lindgren [3] reported a small mass of chromite exposed on the serpentine close to Gillespie's sawmill, 7 miles south of Prairie City, and mentions heavy float of chromite close by the placer mines of Winterville.[4]

A large quantity of ore was taken out in the fall of 1916 at the head of Quartz Gulch, on the property of McCorkle & Beggs, the ore ranging from 40 to 50 per cent of chromic oxide, and was hauled to Prairie City for shipment.

A. J. Collier [5] reported that "on the south side of John Day River, opposite the mouth of Cumming Creek, in sec. 21, T. 13 S., R. 28 E., there is a large deposit of dark-colored serpentine, and in contact with it a body of chromite was found." Collier estimates that at this locality there are several carloads of residual chrome ore on the surface, and the sample of ore which he collected was found by the Geological Survey to contain 49.6 per cent of $Cr_2O_3$. The ore is exposed near the wagon road and could be easily hauled up the river 33 miles to Prairie City for shipment.

Some large boulders of chromite occur on Conner Creek, 15 miles from Huntington. A chemical analysis by Dolbear gave chromic oxide, 50.45 per cent; silica, 5.80 per cent.

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[1] U. S. Geol. Survey Geol. Atlas, Roseburg (No. 49), Coos Bay (No. 73), and Port Orford (No. 89) folios; Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 20, 46, 1914; U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pl. 64, 1901.

[2] U. S. Geol. Survey Bull. 285, pp. 150-163, 1906.

[3] U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, p. 638, 1901.

[4] Attention is called to the same deposit by the Oregon Bureau of Mines and Geology in Mineral Resources of Oregon, October, 1914, pp. 50-53.

[5] Mineral Resources of Oregon, vol. 1, No. 3, p. 42, 1914.

*Douglas County.*—The operations in Douglas County were southwest of Riddle, on the slope of Nickel Mountain. The intrusive rock, saxonite, is partly altered to serpentine and contains irregular nodules and scattered masses of chromite. In places the grains and fragments of chromite are abundant in the green nickel ore (garnierite). This is a matter of great interest as the same minerals are associated in the great chrome and nickel mines of New Caledonia. As elsewhere, the chromite is most abundant near the surface. Much of it is high grade, containing, according to W. Q. Brown, 55 per cent of chromic oxide. The high grade of the ore is shown also by the average of six analyses reported by Dolbear, as follows: $Cr_2O_3$, 53.21; $SiO_2$, 3.23; MgO, 1.94. The ore dug from the small open pits is hauled over a good road 6 miles (descent 2,900 feet) to the main line of the Southern Pacific Co. at Riddle. Farther south, though still in Douglas County, there were several other points of production, but the ore was of lower grade, ranging from 40 to 46 per cent of $Cr_2O_3$. The total output for Douglas and Grant counties in 1916 was 956 long tons.

*Josephine County.*—Josephine County, in the northern Klamath Mountains, has the largest area of serpentine in the State and is the premier county in the production of chromite. The most northern point of production is on Coyote Creek, but the most active centers are near the stage road and the developing railroad line advancing from Grants Pass to Crescent City. The railroad is crossing the great serpentine belt and will greatly facilitate the development of the chrome industry in southwestern Oregon and northwestern California. The total sales of chrome ore in 1916 for the county amounted to 2,143 tons. The earlier developments were in the Waldo region and on Josephine Creek and Briggs Creek where several smaller masses were mined out, but with the opening of the Collard & Moore property near Holland, 20 miles southeast of Kerby, the output assumed a more regular and promising aspect.

This deposit, the largest thus far developed in Oregon, is connected with a mass of serpentine and associated basic intrusive rocks that penetrate the Paleozoic sediments southeast of the great mass of serpentine. The ore is hauled in wagons about a mile down steep mountain slopes to a bunker where it is loaded on motor trucks for transportation about 25 miles to the California & Oregon Coast Railroad station for shipment. The small outcrop of chromite proves to be the top of a large body, the upper portion of which can be removed in an open cut quarry but the deeper portion is being mined by underground workings. It was opened last winter to a depth of 60 feet, 50 feet in width, with good ore on all sides, top, and bottom, but it has since caved in. The ore averages about 40 per cent of chromic oxide, but there is a considerable and irregular range in its composition. The average analyses of 15 cars reported by Dolbear is 36.71 per cent of chromic oxide and 11.91 per cent of silica.

The ore at the bottom of the mine, as noted by Dolbear, is of lower grade than that near the surface. The same observation was made by Van Fleet near Callahan.

On account of the lower grade of much of the ore about the Collard & Moore mine, a concentrating plant has been erected. It consists of standard rolls, jig, and concentrating table. At the time of the writer's visit, July 18, 1917, the mill was operating upon the residual sands of the mine and yielding about 6 tons of concentrates daily.

The sands contain 25 to 35 per cent and the concentrates about 55 per cent of $Cr_2O_3$. It is proposed to add a rock crusher at the mine and sluice the product to the mill.

*Coos County.*—Within the Port Orford quadrangle [1] on Johnson Mountain and Iron Mountain southeast of Eckley, near the boundary line between Coos and Curry counties, are large masses of serpentine containing numerous grains of chromite. Near the south end of Johnson Mountain, within the serpentine area of Coos County, there is a small mass of chromite in place and boulders are scattered over an area of several hundred acres. The size and abundance of these boulders suggests a large body of chromite beneath, but there has not been sufficient development work to demonstrate that it is not a case of surface enrichment by disintegration and erosion of the serpentine. Dolbear's analysis shows about 50 per cent of $Cr_2O_3$ and 5 or 6 per cent of $SiO_2$. He reports another body of chromite on Johnson Creek and notes the occurrence of the nickel ore genthite. Both of these localities are far from wagon roads and 40 miles from the nearest railroad of the Coos Bay region.

*Curry County.*—Curry County, although on the coast, is without a good harbor or railroad. The only wagon road leading south to Crescent City in California and north to Marshfield on Coos Bay is remarkable for its scenic beauty but without the grading necessary for economic commercial traffic. Although there is much chromite in the county its present relation to market prohibits exploitation.

Two specimens of chromite from widely separated localities in Curry County were analyzed by the Oregon Bureau of Mines and Geology,[2] with the following results:

*Analyses of chromite from Curry County, Oreg.*

| | 1 | 2 |
|---|---|---|
| Chromic oxide | 45.99 | 48.09 |
| Iron | 20.41 | 16.44 |
| Silica | 21.33 | 19.78 |
| Alumina | 2.14 | 8.12 |

No magnesia in either sample, and a trace of titanium in the second sample. These analyses indicate that the ore is of fair grade so far as the chromium content is concerned, but that it is of unusual character in two particulars. The first of these is the total absence of magnesia, and the second is the unusually high percentage of silica.

As has already been stated, the total marketed production of chromite during 1916 in Oregon (combined with that of Wyoming and Maryland to avoid disclosing the output of individual producers) amounted to 3,277 long tons, valued at $43,306.

## CALIFORNIA.

A few years ago California was the only State in this country producing chromite, and it still is by far the largest producer.

Attention is called to the numerous occurrences of chromite pointed out in the publications of the California State Mining Bureau.[3] To

[1] U. S. Geol. Survey Geol. Atlas, Port Orford folio (No. 89), 1903.
[2] Mineral Resources of Oregon, vol. 2, No. 2, p. 67, 1916.
[3] The principal reports of the California State Mining Bureau concerning chromite are Bull. 38, published in 1906, and the annual reports of the State Mineralogist, especially the reports on mines and mineral resources of the several counties, published in the annual report for 1913–14 (July, 1915).

the earlier publications of that bureau full references were made in the United States Geological Survey report on chromite for 1908 by E. C. Harder.[1]

*Siskiyou County.*—Siskiyou County with its large areas of serpentine has many deposits of chrome ore, but only those were worked that are within comparatively easy reach of available roads, particularly those west of Yreka and Gazelle, where much of the output was delivered for railroad shipment. Much ore was produced near Callahan and farther north, and some near Montague, but the greater part was quarried along the southern border of the county near Dunsmuir, on the north slope of Little Castle Creek, at the Coggins mine, practically in line with and in plain view of the great body of chromite of Shasta County, on the south slope of Little Castle Creek. In the Callahan region the ore averaged nearly 50 per cent of chromic oxide, near Montague only 30 per cent, and near Dunsmuir it ranged from 37 to 40 per cent. Perhaps there were producers in Siskiyou County whose reports were not received; reports from five producers gave the marketed output in 1916 as about 1,700 long tons.

*Del Norte County.*—The chrome deposits of Del Norte County were among the first in California to attract the attention of capitalists,[2] because of the good character of the ore. At Chrome Hill, near Low Divide on the Tyson property, according to Dolbear, the ore contains chromic oxide 47.33 per cent, silica 3.82 per cent. Five samples were taken by the same authority from the French Hill ore body, 19 miles northeast of Crescent City, and an average of their closely agreeing analyses showed a content of chromic oxide of 46.49 per cent, silica 4.28 per cent. At present, shipment by boat from Crescent City may be the only outlet, but the railroad from Grants Pass to Crescent City may soon be available. This seems all the more probable if, as is now reported, the Twohy Brothers, who control the branch railroad, have become interested in the Tyson mines near Low Divide, on the old stage road about 10 miles east of Smith River Corner and 24 miles from Crescent City.

With improved transportation other discoveries may be expected in the large serpentine area in the eastern part of Del Norte County.

*Shasta County.*—The chromite of Shasta County, being in a belt of serpentine running north and south near the main line of the Southern Pacific Railroad from Dunsmuir to Gibson, is favorably located with reference to transportation and has received much attention from prospectors. Then, too, some of the bodies of ore are large and so situated on the transverse canyon slopes as to be easily mined and handled. This advantageous condition has kept Shasta County for many years in the front rank of domestic producers of chrome ore; the production in 1916 was more than 11,000 tons.

The largest known body of chromite on the Pacific coast is in Shasta County in what was formerly called the Brown mine,[3] on the south slope of Little Castle Creek, 3 miles south of Dunsmuir. This mine was acquired by the California Chrome Co. in 1915, and the

[1] U. S. Geol. Survey Mineral Resources, 1908, pt. 1, pp. 766–770, 1909.
[2] Mines and mineral resources of Del Norte County: California State Mining Bur. Ann. Rept., 1913–14, p. 10, 1915.
[3] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 10, 1916.

engineer in charge, Mr. J. R. Van Fleet, has kindly furnished the accompanying plan (fig. 1) and sections (figs. 2 and 3) and most of the notes concerning this great ore body.

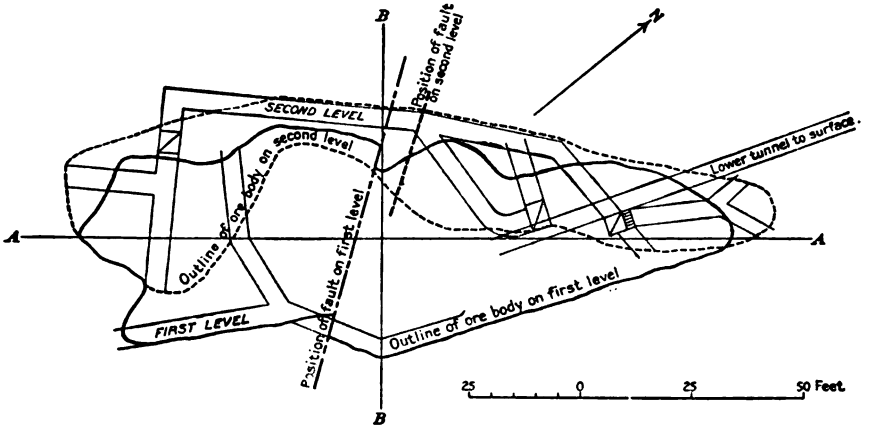



FIGURE 1.—Plan of chromite deposit on Little Castle Creek, Shasta County, Cal.

The ore body illustrated above on the first mine level is 146 feet long in a direction N. 40° E. and 40 feet wide, with a height of 54 feet. On the second mine level 30 feet below, the length has increased to nearly 160 feet but [the ore body has] decreased by half in width and thickness.

The country rock of the chromite ore body is in part peridotite but chiefly pyroxenite, which exhibits large cleavage surfaces often several feet in extent. These cleavage surfaces are sometimes spotted with grains of olivine, giving the surface a decidedly greenish color. Along the east wall the pyroxenite has been altered into

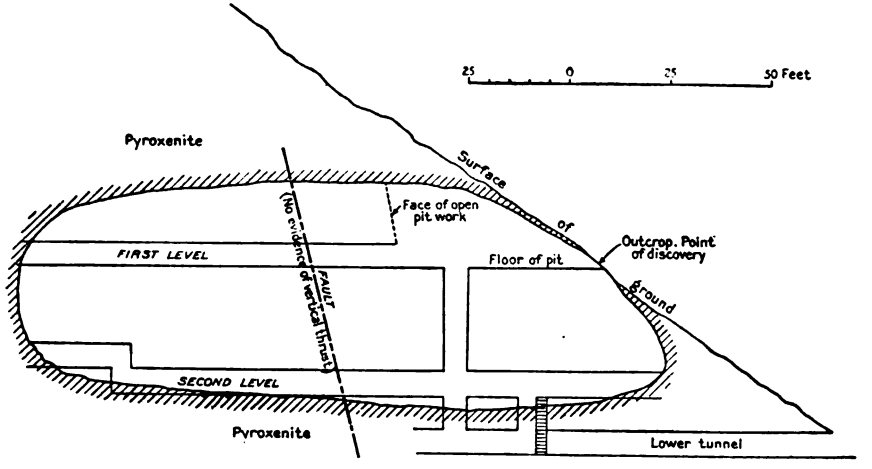



FIGURE 2.—Longitudinal section of chromite deposit on Little Castle Creek, Shasta County, Cal.

serpentine, which gradually merges into the parent rock in a few feet. On the south end of the ore body there was a mass of heavy black rock, probably dunite, which to the unitiated was easily mistaken for chromite. Along the east wall there was a decided line of cleavage between the ore and the wall, the ore coming away freely and clean; while on the west side there was no line of demarcation, the ore grading off into the wall rock and often large masses of the wall rock intruding into the ore body. This same occurrence also existed on the top 10 feet of the south end. The ore body was characterized by numerous seams throughout. These seams were filled

with a clay gouge containing fine particles of chromite and olivine, were from the thickness of a knife blade to several inches in width, and the surfaces of the chromite adjacent were smooth but showed no striations due to faulting. There was no system of these seams apparent except that they were generally wedge shaped, always with the large end down, making the ore exceedingly heavy and hard to hold with timbers. There was one well-defined fault, which penetrated the ore body about through its center of mass in a northwesterly direction, and like the ore body dipped to the northeast about 75°. The position of this fault is shown at both levels on the plan of the deposit submitted. No evidence of any vertical throw was found, but there was a transverse or horizontal throw of about 5 feet on the first level. On the second level there was no throw observed. Along this fault plane there was a zone of about 4 feet in thickness of muddy clay containing fragments of chromite from fine particles to several hundred pounds in size. The walls of the adjacent chromite were smooth.

In view of the early production of the deposit, reported to the Geological Survey by Mr. Brown, it appears to be safe to estimate the production of this ore body at 12,000 tons of merchantable ore. There was a shrinkage in washing and grading of about one-third, so that the contents within the limits of the ore body might approximate 18,000 tons.

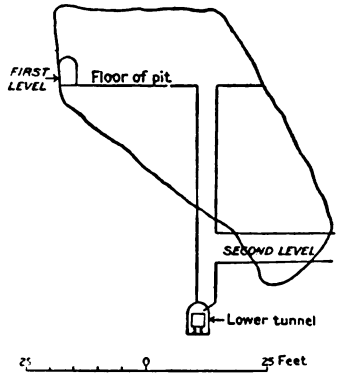



FIGURE 3.—Transverse section of chromite deposit on Little Castle Creek, Shasta County, Cal.

Concerning other deposits, Mr. Van Fleet remarks:

> It has been my experience that the chromic oxide content of ore in a deposit varies considerably. Almost invariably I have found the outcrop and float of smaller deposits to be the best material. In one case, near Callahan in Siskiyou County, this occurrence was so marked that the lower portions of the deposit were not of marketable quality. Also in the smaller deposits, when there is a well-defined cleavage between the inclosing rock and the chromite on all sides, the ore throughout is of about the same grade. Where there is a hard rib or zone in the deposit, the hard rib of ore is of higher grade than that surrounding it. Of course, this would hold only when the hardness is not due to an impurity. This occurrence was particularly marked in the Little Castle Creek deposit. Where there is no line of cleavage between the ore and the wall rock, there are apt to be intrusions of the surrounding rock into the ore body. The grade of the ore decreases near these intrusions and the ore is quite frequently cut off abruptly.

The run of the ore as marketed has been reported to contain 45 per cent of chromic oxide, but this may be higher than the average.

A mile to the northeast of this ore body and in line with it in Siskiyou County is another large body that is being mined. The serpentine area carrying other bodies of chromite extends for miles to the south, and the chrome ore is worked at a number of other points in Shasta County.

One of the principal points of production in 1916, operated at first on lease but later purchased by the Manganese Co. of California, is 4 miles west of Gibson. On smaller bodies occurring near Sims and on Shotgun Creek there was considerable activity a dozen years ago. The ore bodies had characteristics like those of the great body on Little Castle Creek described by Mr. Van Fleet.

Heroult, on Pit River, in Shasta County, is the location of the plant of the Noble Electric Steel Co.,[1] where three furnaces are being operated to capacity, producing ferromanganese and ferrochrome.

[1] Eng. and Min. Jour., Nov. 4, 1916, p. 845.

*Trinity County.*—Trinity County, among the rugged Klamath Mountains, contains large masses of serpentine in its northeastern portion, which adjoins the highly productive part of Shasta County and may well be expected to contain important bodies of chromite; this region is, however, beyond the present limits of economic transportation. In the southern part of the county near Wildwood there are several masses in reach of the State highway from Red Bluff to Eureka, and there has been a considerable production from surface boulders that contain from 46 to 55 per cent of chromic oxide. The ore was hauled across the mountain to the railroad at Redding.

*Tehama County.*—Some years ago chrome ore was hauled from Elder Creek, west of Lowrey, 25 miles to Red Bluff. Production ceased in 1898 but was begun again in 1916 in the same region on the property of the Noble Electric Steel Co., where important bodies were opened at 2,000 feet above sea level and a large quantity of ore containing about 45 per cent of $Cr_2O_3$ was removed. The ore is well exposed on the steep south slope of the canyon of Elder Creek and is hauled in wagons 4 miles to a dump, from which it is taken by auto trucks to Red Bluff. Several other bodies of chrome ore have been discovered in that region and two of them are large producers.

*Glenn County.*—Glenn County has recently been the scene of remarkable activity in mining chrome ore. The California Chrome Co. purchased a number of claims on the red mountain slope 2 miles west of Milsap. In the serpentine belt many ore bodies, some small, others large, were mined out, and the ore was hauled in trucks 15 miles to Fruito. The work closed in September, 1916, pending further prospecting for new deposits. Although the general belt of serpentine areas runs nearly south from Siskiyou through Shasta, Tehama, and Glenn counties into Lake and Napa counties, the bodies of chrome ore in this belt generally have their greatest extension nearly northeast and make a large angle with the general course of the serpentine belt. The same discordance between the general trend of the bodies of chrome ore and that of the serpentine in which they occur was noted in the Sierra Nevada.

*Lake County.*—The Lucky Strike claim, discovered in September, 1916, in the Lower Lake region near Reiff post office, was actively operated for some time upon high-grade ore. The output was used for tanning. Bad roads stopped work for the winter.

*Sonoma, Solano, and Mendocino counties.*—A small production was reported in 1916 for Sonoma County and also for Solano County. Several prospects were opened in Mendocino County. Dolbear reports a small deposit about 40 miles north of Fort Bragg and gives the following analyses of two samples.

*Analyses of chromite from Mendocino County, Cal.*

| | 1 | 2 |
|---|---|---|
| Chromic oxide | 56.36 | 49.79 |
| Silica | 2.30 | 6.20 |

Several deposits are reported in the vicinity of Ukiah.[1]

[1] Mines and mineral resources of Del Norte, Humboldt, and Mendocino counties: California State Min. Bur. Ann. Rept. for 1913-14, p. 50, 1915.

*Napa County.*—Chromite has long been known from Pope and Chiles valleys in Napa County, but there was no production until 1916. The two principal points of production were in secs. 28, 33, and 34, T. 8 N., R. 4 W., about 7 miles northeast of St. Helena. The ore ranged from 41 to 51 per cent of chromic oxide. There were five producers and the total output of the county was about 447 long tons. Perhaps as a result of this promise of production a chrome tannery, which requires high-grade ore, was established on tidewater at Napa. Notwithstanding the reports of ore containing 50 per cent of chromic oxide it has been the experience of those buying high-grade ore on the Pacific coast that the quantity of chrome ore in California containing 48 per cent of chromic oxide is very small, and it is said to be practically impossible to get a steady local supply that will run over 45 per cent of chromic oxide. It is hoped, however, that this difficulty may be met by concentrating ore of lower grade.

*Marin, San Francisco, San Mateo, Santa Cruz, San Benito, Monterey, Santa Barbara, and Los Angeles counties.*—The occurrence of chromite has been noted by the California State Mining Bureau in Marin, San Francisco, San Mateo, Santa Cruz, San Benito, Monterey, Santa Barbara, and Los Angeles counties,[1] but no sales of chromite in 1916 were reported from these counties.

*Alameda County.*—In Alameda County, southeast of Livermore, deposits of chrome ore have been reported at two places[2]—one at the Douglas and Mendenhall mines, 15 miles from Livermore, and the other at the Jones mine, 20 miles from Livermore. In 1916 there was a production in that region on land owned by Samuel H. Newman.

*Santa Clara County.*—Small bodies of chrome ore were discovered and removed recently from the vicinity of Los Gatos and New Almaden.

*Stanislaus County.*—Chromite was produced in 1916 by the Mineral Products Co. west of Patterson, in Stanislaus County, and the larger part of the output was sold.

*San Luis Obispo County.*—San Luis Obispo County lies on the coast. As it is traversed by the Southern Pacific Railroad and has a branch line to the coast at Port San Luis, it has convenient shipping facilities, both inland and to the sea. The numerous bodies of serpentine containing deposits of chromite[3] afford considerable production. Numerous bodies of chromite, some large ones, are reported along the slope of the Santa Lucia Range northwest of San Luis Obispo, and smaller bodies occur in the opposite direction. Five producers in the county in 1916 made a total output of about 1,945 long tons. Many of the ore bodies are small and much of the ore is low grade, suggesting the need of concentration.

*Tulare and Inyo counties.*—The ore bodies on Dr. D. A. Vaughan's property, 5 miles southeast of Porterville, Tulare County, mined in the spring of 1916, were in impure serpentine derived from a rock so rich in pyroxene as to be practically a pyroxenite. There were two large irregularly lenticular ore bodies, the greatest diameters of which were approximately from north to south and in line about 100 yards apart. The schistose structure of the inclosing serpentine is from northwest to southeast. Other openings near by showed chromite, and although much ore had been removed and work had ceased the

[1] U. S. Geol. Survey Mineral Resources, 1908, pt. 1, pp. 766–770, 1909.
[2] Idem, p. 767.
[3] Fairbanks, H. W., U. S. Geol. Survey Geol. Atlas, San Luis folio (No. 101), 1904.

deposits were not completely exhausted. The ore is jet-black but rather dull and is said to contain 50 per cent of chromic oxide. In places the coarsely crystalline structure was distinct.

There were at least three other smaller producing mines in Tulare County and a small production was reported from Inyo County—a total output for the two counties in 1916 of more than 1,600 long tons.

*Fresno County.*—One of the most productive serpentine areas of the State is about 27 miles northeast of Fresno. The area is several miles in width and has a length from northwest to southeast of not less than 10 miles; it crosses Kings River a few miles west of Trimmer post office and forms Hog Mountain, which has an altitude of about 2,700 feet, and the hills about Watts Valley. The principal points of production are on the slopes of Hog Mountain and about Watts Valley. The ore from the Hog Mountain region is hauled from 6 to 10 miles to Piedra or Sanger and that from the Watts Valley region is hauled 30 miles to Clovis for shipment.

The majority of the ore bodies in the Hog Mountain region were small. Those of the Watts Valley region were somewhat larger, and the one in the Clara H. mine yielded before July 1, 1916, more than 1,000 tons. The ore body near the surface was about 100 feet in length from northeast to southwest and 40 feet in width. Being a mixture of nodules and lumps of chromite in disintegrated serpentine, the ore body is soft and easily worked with pick and shovel. Much of the chrome is hand picked in mining. The range in composition of the ore, according to L. E. Ailport, the mine superintendent in that locality for the Manganese Co. of California, is from 39 to 43 per cent of chromic oxide. The principal shippers from the Hog Mountain and Watts Valley region are the Manganese Co. of California, the Mineral Resources Co., and Frank Carson. There is, of course, a considerable output not yet sold and shipped, but it is not counted in this report as production. There has been a small production of chromite in the western portion of Fresno County with delivery at Coalinga, but details of sales are not available.

*Tuolumne County.*—The production of chromite in Tuolumne County is mainly in the region of Chinese Camp, Jamestown, and Tuttletown, where five producers sold in 1916 more than 500 long tons containing approximately 40 per cent of chromic oxide. W. E. Booker, of Jamestown, and C. A. Gillis, of Tuttletown, have handled much of the ore.

*Calaveras County.*—Calaveras County has shipped ore from half a dozen mines and has a total output of nearly 1,000 long tons containing about 30 per cent of chromic oxide and 7 per cent of silica. The Vogelsang and Ellingwood ore bodies, 5 miles southeast of Valley Springs, described by Harder,[1] were mined in the summer of 1916, and, although they yielded more than 100 tons each, they fell below their estimated contents; they illustrate the difficulty in giving due consideration to surface enrichment in chromite by weathering and erosion of serpentine.

Other bodies of chromite have been found in the serpentine of Calaveras County. Perhaps the most important property worked in the county is that of John Madrid, 8 miles northeast of Angels Camp; but it is surprising to find that the black lustrous ore of that locality contains only about 30 per cent of chromic oxide, a fact

[1] U. S. Geol. Survey Bull. 430, pp. 174-176, 1909.

which is regarded as probably due to the presence of magnetite. J. A. Maxwell and P. S. Dean, both of Felix, have delivered their ore at Angels Camp.

*Amador County.*—The prominent belt of serpentine that extends northwest across Calaveras and Amador counties and contains most of the important chrome deposits in both counties has been mapped by Turner.[1] Although the ore bodies were first developed in Calaveras County, Amador County has recently become an important producer and Ione is the principal point of shipment.

*Eldorado County.*—Eldorado County has recently become one of the largest producers of chrome ore; the output in 1916 was nearly 3,500 long tons, valued at about $49,000. The largest deposits mined were 10 to 14 miles northeast of Folsom, in the vicinity of Negro Hill and Pilot Hill. There were eight producers, and Folsom was the chief point of shipment.

*Placer County.*—Bodies of chrome ore have been worked by five operators in Placer County, with a total output of 579 long tons, and the principal points of production have been in the neighborhood of Alta, Towle, and Iowa Hill.

*Nevada County.*—Nevada County, though not previously reported as producing chromite, had a considerable number of producers with a good production in 1916.

*Butte County.*—All the chrome ore produced in Butte County was mined by the Zenith Chrome Mining Co. Most of it came from near Forbestown but several small bodies were found near Pentz. Four or more bodies of ore were removed near Forbestown within a distance of about 8 miles; they ranged in size from a few tons to deposits of approximately 400 tons. In composition the ore ranged from 36 to 42 per cent of chromic oxide and from 3 to 6 per cent of silica. The ore was hauled about 23 miles in motor trucks to Oroville for shipment.

*Plumas County.*—The most northern commercial bodies of chromite yet found in the Sierra Nevada occur in serpentine, 6 miles west of Greenville. The larger portion of one body was removed, but the haul to the main line of the Western Pacific Railroad at Keddie was too long for fair profits, but now that a branch road comes near Greenville other ore bodies that have been prospected are made more available. It is said, however, that the ore of that region contains only about 30 per cent of chromic oxide.

## CHROMITE IN CANADA.[2]

*Quebec.*—New record figures, both in tonnage and in value (27,055 tons, $299,070), were reached in 1916 in the shipments of chromite from the Coleraine-Black Lake district. Of these shipments about 40 per cent was exported to the United States. The prevailing prices were very satisfactory, and in the latter part of the year the scale in force for chromite f. o. b. Quebec Central Railway's stations was 50 per cent ore, $45 a ton; 40 per cent ore, $38.75; 30 per cent ore, $22.50; 25 per cent ore, $18. For special purposes ore higher than 50 per cent can be marketed at $1 a unit.

The two concentrating mills of the Mutual Chemical Co. of Canada, one at Black Lake and the other on lot 7, range B, of Coleraine, are now in operation and deserve special consideration.

[1] U. S. Geol. Survey Geol. Atlas, Jackson folio (No. 11), 1894. [2] Canadian Min. Jour., Mar. 15, 1917.

## CONCENTRATION OF CHROME ORES.

The concentration of chrome ores is becoming a matter of much importance in the United States. At the request of the United States Geological Survey the Mutual Chemical Co. of Canada (under date of Apr. 24, 1917) has kindly furnished the following account of its mills in successful operation concentrating chrome ore at Black Lake, Province of Quebec, Canada:

The Mutual Chemical Co. of Canada (Ltd.) is operating two chrome concentrators in this district, the Lake Side mill, under lease from a local company, and the St. Francis mill, a new mill built during the summer of 1916 on chrome properties controlled by the company.

*Lake Side mill.*—The Lake Side mill is situated about 2 miles south of the town of Black Lake, on the line of the Quebec Central Railroad. This mill, built some 15 years ago and abandoned in 1909, was refitted along the original lines during the summer of 1916. The equipment consists of—

Receiving bin, capacity 75 tons.
One 9 by 15-inch Blake jaw crusher.
Elevating and conveying equipment for distribution of ore to stamp battery bins; capacity 35 tons each.
Thirty 950-pound gravity stamps.
Seven 16-foot Wilfley tables.
Concentrate collector boxes and storage shed for concentrates.
Water-storage tank.

Ore is hauled to the plant by wagons, which deliver either into the mill bins or stock pile, as desired.

The plant is driven by electric power. The water supply is pumped from Black Lake, a distance of 700 yards, under head of 180 feet, by means of a 7 by 9 inch triplex plunger pump, belt driven.

The essential features of the milling system are as follows: (*a*) Reduction of ore to about 2-inch maximum size by means of the jaw crusher; (*b*) grinding in stamps to pass 20-mesh screen; (*c*) stamp product fed directly to Wilfley tables; (*d*) middlings from six tables, without regrinding, reconcentrated on one table, to which they flow by gravity.

It will be seen at a glance that the above outline embodies the simplest possible system of gravity concentration, corresponding to concentration practice of some 15 or 20 years ago. In refitting the mill, the original design was, nevertheless, adhered to, as the very limited tonnage of milling ore that could be assured at the time made it advisable to limit expenditures to the minimum.

The milling results covering the eight months of operation, August 1, 1916, to April 1, 1917, are substantially as follows:

| | | |
|---|---|---|
| Ore milled per day | long tons | 70 |
| Total water consumption per ton of ore milled | do | 7–8 |
| Average content in chromic oxide | per cent | 12 |
| Percentage recovery | do | 65.8 |

*St. Francis mill.*—This mill, built during the latter half of 1916, at the company's own mines, is located about 4½ miles southeast of the village of Black Lake. The nominal capacity of the mill is 80 tons per 24 hours. Electric power is used throughout.

The requisite water supply, 65 gallons per minute, is pumped a distance of seven-eighths of a mile from a small lake approximately 120 feet below the level of the main storage tank located near the mill.

The attached skeleton flow sheet (fig. 4) indicates the milling system and equipment employed.

Attention might be called to the following conditions which influenced the design of this plant:

1. *Desirability of economy in water consumption.*—Excess water in slimes produced in grinding, as well as excess water from all the tables, is returned to the Dorr thickener, where the contained solids are settled out and the recovered clear water made available for reuse.

The net loss of water is thus reduced to substantially the amount required to carry away the tailings.

2. *Asbestos fiber in the ore.*—In the earlier stamp milling of the ore a good deal of difficulty was encountered as a result of the "blinding" of the battery screens by

this fiber. The idea that this difficulty would be entirely avoided by the use of the Callow traveling-belt screen has been proved to be correct during the short time that the mill has been in operation. It has also been found in actual operation that a considerable portion of the fine asbestos fiber is floated out in the slimes overflow of the Dorr classifier.

3. *Chromite in the slimes.*—It will be noted in the accompanying flow sheet that no provision was made for the concentration of the slimes produced in grinding. It was reasoned that by providing ample capacity in the Dorr classifier the operation of this classifier could be so controlled as to effect the settlement, along with the sands product, of a large proportion of the slimed chromite.

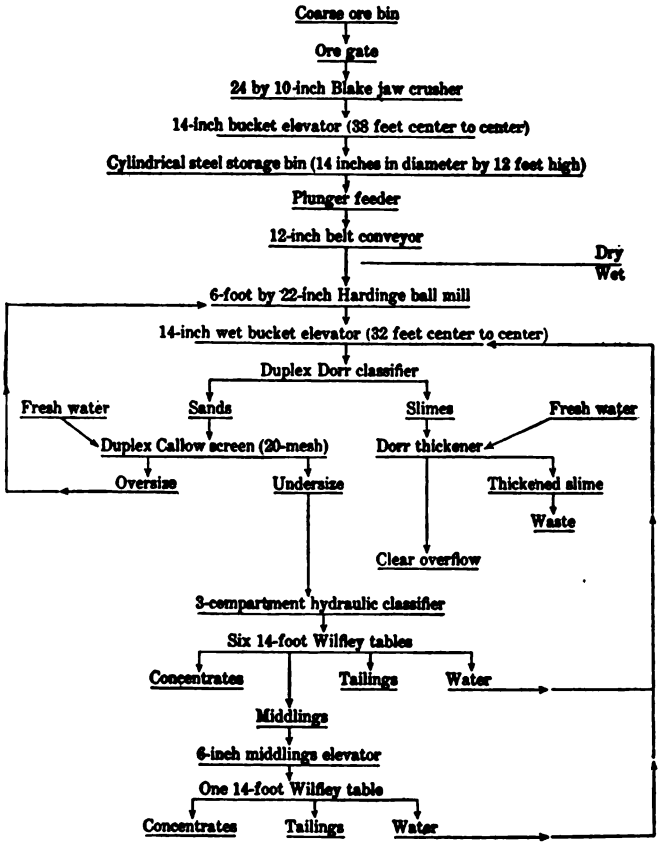



FIGURE 4.—Flow sheet of St. Francis mill of Mutual Chemical Co. of Canada, near Black Lake, Quebec.

Operations thus far have shown that this settlement takes place to a considerable extent, but the mill has not yet been in operation for a sufficient period to allow of reaching a definite conclusion as to whether slimes concentration can profitably be dispensed with.

It might be added that the normal price of chromite concentrates, carrying 50 per cent of chromic oxide, fixes a limit on operating cost, which does not permit of elaborate refinements in the system of concentration employed.

The equipment noted is all standard equipment in wide use in wet milling practice, and its use in this case is novel only as being applied to the treatment of chrome ores.

## RECENT PUBLICATIONS CONCERNING CHROMITE.

DOLBEAR, S. H., The nature of chromic-iron deposits: Min. and Sci. Press, Apr. 21, 1917, pp. 552–554.

Intended especially for miners to enable them to prospect more intelligently and avoid needless disappointment. Chromite occurs as an accessory mineral in basic igneous rocks, peridotite and pyroxenite, which are made of olivine and pyroxene. Being highly infusible and insoluble chromite is one of the first minerals to crystallize out of the molten rock magma, and under favoring conditions may sink to near the bottom and form horizontal lenticular ore bodies. By folding and faulting the bodies of chromite may be bent and broken so as to appear in many different positions. The miner may gain much important information to guide his development work by studying the position of the ore body in each case.

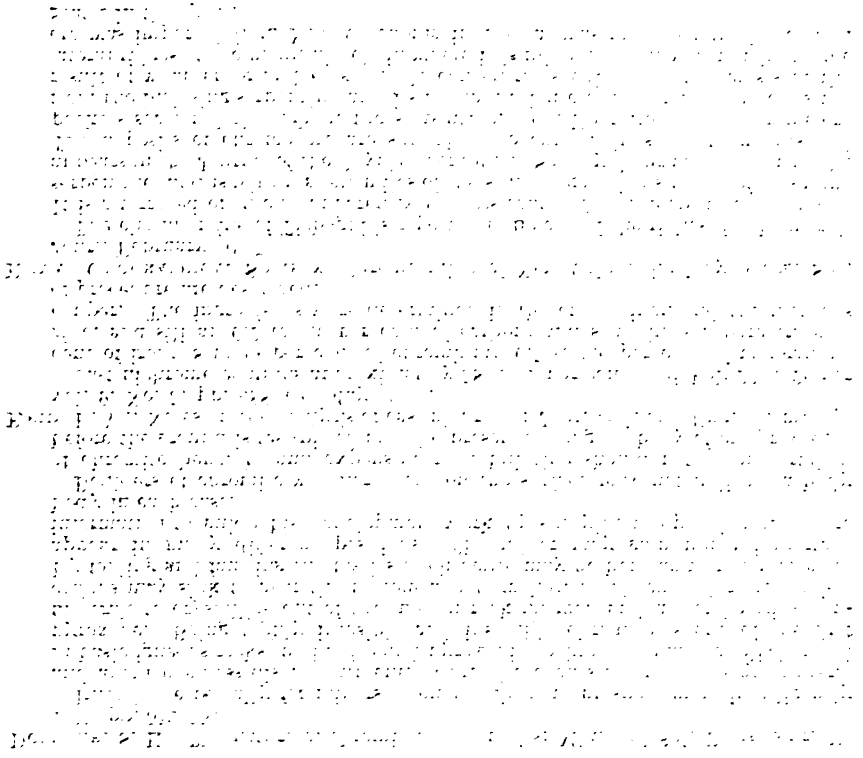
Boulders of chromite weathered out on the surface may not indicate a body of chromite beneath, and expensive road building should not be undertaken before the ground is test-pitted and the presence of a good body of ore proved.

REID, E. W., Notes on the analysis of cast nichrome: Jour. Ind. and Eng. Chemistry, vol. 9, No. 5, pp. 488–490, May, 1917.

Cast nichrome contains approximately 58 to 62 per cent of nickel; 23 to 26 per cent of iron; 8 to 14 per cent of chromium; 0.5 to 2.0 per cent of manganese, zinc, and silica; 0.2 to 1.0 per cent of carbon; and sometimes a bare trace of copper. The ingredients were determined in the order given and the methods of procedure are described.

ROYAL GEOGRAPHICAL SOCIETY, Chrome mine of New Caledonia: Roy. Geog. Soc. Jour., February, 1917.

The chrome mine of Tiebaghi is reported to be one of the richest in the world. It is a terraced open cut, apparently not less than 100 feet deep, in decomposed serpentine, and is within a few miles of the sea. A good illustration of this mine appears in the Journal of the Royal Geographical Society, February, 1917, page 93. The deposits of chrome ore are superficial, occurring in small fragments and pockets scattered throughout the serpentine. The liberation of the chrome ore from the inclosing serpentine and its accumulation on or near the surface is the result of weathering and erosion. It concentrates chiefly on the crests of the lateral ridges of the mountain chain where it is mined. Nearly as much chrome ore was imported from New Caledonia in 1916 as was produced in the United States in that year.



# SECONDARY METALS.

By J. P. Dunlop.

## INTRODUCTION.

### SCOPE OF REPORT.

"Secondary metals" are those recovered from scrap metal, sweepings, skimmings, and drosses, and are so called to distinguish them from the metals derived directly from ores, which are termed "primary metals." The distinction does not imply that secondary metals are of inferior quality, for metals derived whether from ore or from waste material vary in purity and in adaptability for use in making certain products. The reports to the United States Geological Survey now include the secondary recoveries of copper, zinc, lead, tin, antimony, and aluminum, and in 1916 the inquiry was extended to include nickel. The figures obtained by the Survey are given as a supplement to the regular reports on primary metals in order to enable producers and consumers to form a more comprehensive idea of the quantities of metal available for consumption; in fact, they constitute an essential addition to the seven general reports on primary metals, though only a part of the recovery of waste metals is given.

### RECOVERY OF WASTE MATERIAL.

The much higher prices for all metal products and for manufactured articles made wholly or in part from waste material has made a deep impression as to the importance of the waste-trade industry. The collection of old metals, paper bags, foil, rags, felt, and other things has been stimulated by appeals from many sources. Collections of metal have been so large that it has been difficult to obtain labor properly to break, segregate, and ship the varied classes of material. In fact, the public has been educated sufficiently to appreciate the importance of waste; even the farmers in remote regions are being asked to collect and ship scrap iron, steel, and other metals. Efforts are now being made to have the housekeepers and small dealers properly segregate the different wastes, for by so doing better prices can be obtained and an immense amount of labor can be saved. The large manufacturing plants, foundries, and smelters have increased their facilities for saving and segregating scrap metals and have also adopted methods for decreasing melting losses. They have realized that more scrap metals can be used if greater care is taken in removing deleterious substances and in better smelting practice.

The manufacturers of the Noble and the Dings magnetic separators state that the sales of their products have shown a very large increase in the last two years. The chief use for their separators was for the magnetic concentration of metals. One of the main uses now is for the elimination of iron from brass and other nonferrous metals. The use of magnetic separators has been greatly extended, and they are now used to protect crushers, grinders, and conveyors in rock quarries, sugar factories, tobacco factories, fertilizer plants, and many other manufacturing industries, by eliminating metallic substances which have accidentally fallen into the feed. Iron and steel filings are thus recovered from sands, ashes, and other foundry refuse. In the manufacture of pottery, glassware, etc., the clay and sands are run through a magnetic device to extract small particles of iron. The graphite used in the manufacture of crucibles contains some iron, which is removed magnetically. Used crucibles at smelting plants are crushed, the iron is extracted, and the clay is made suitable for reuse. Broken tire studs and nails are removed from old reclaimed rubber, and manganese and bronze are separated from ordinary red or yellow brass by means of magnetic separators.

Efforts also are being made to reduce the losses occurring in melting light scrap. The Metal Industry,[1] in describing a new briquetting machine installed at the Chase Metal Works in Waterbury, Conn., states:

> Among the features of the present phenomenal rise in labor and raw materials costs is the very evident determination to cut avoidable losses to the lowest level possible. With an abundance of capital available, installations for recovery of values from what seemed unavoidable waste are springing up everywhere, for it is known that when the slump due on the close of the European war arrives our manufacturing establishments should be prepared.
>
> One of the most interesting developments of special importance to the metal industry is the saving of values by preventing excessive oxidation when melting copper, light brass, bronze, aluminum, and other scrap. This is accomplished by subjecting this material to enormous pressures and thereby consolidating the innumerable small particles into dense, coherent masses, which melt with almost as little loss as the solid metals. In other words, the light scrap is "briquetted."
>
> It is necessary to understand the fundamental action involved when seeking an explanation for the remarkable saving in metal values observed when melting briquets, as compared with the same material treated in the ordinary way. A given quantity of light chips, curls, or needles—"hay," as it is oftentimes called—has an enormous surface area when compared with an equal weight of the same alloy or metal when in solid form. In the application of heat during melting in the crucible or on the hearth the greater the area exposed the greater the oxidation of the metals. Everyone in the business knows this without further proof. If, now, the surface area of a given weight of scrap is reduced to practically the same weight of solid metal, not only will the transmission of heat be better but the oxidation will be vastly lessened.
>
> In extreme cases, where formerly fully 50 per cent of the metal was lost in melting, this has been cut down to one-tenth by the simple process of briquetting. With heavier chips, and especially the high-copper bronzes, this saving is naturally not so marked, for the surface areas, as well as proportions of easily oxidizable ingredients (in the bronzes), is much less.

There are many other phases of conservation relating to the recovery of waste products from foundries and manufacturing plants. An interesting treatise by Arthur F. Taggert, entitled the "Reclamation of brass ashes," was presented at the annual meeting of the

[1] Briquetting brass scrap: Metal Industry, November, 1916, pp. 484–485.

American Institute of Metals, September 11 to 15, 1916. A tentative flow sheet of a plant capable of treating 5 tons of ashes per hour is given. Another paper read at this annual meeting was prepared by J. M. Bateman, and is entitled "How a large manufacturing company disposes of its old metal."

The Geological Survey frequently receives letters inquiring as to the treatment of drosses and skimmings of alloys suitable for certain products and making other technical inquiries, which it is not able to answer though it endeavors to indicate where such information may be obtained. There are many trade papers and journals which give the sources and nature of waste material and the prevailing prices of all kinds of scrap metals. They also contain replies to many questions relating to remelting, refining, proper methods of alloying, etc. Every manufacturing plant using metals and every metal dealer should receive some or all of the following trade journals: American Metal Market, Daily Metal Reporter, the Waste Trade Journal, the Metal Industry, Foundry, and the Brass World.

The ordinary business man also will be better able to form some adequate conception of the vast and vital trade in waste metals and other materials if he includes a journal relating to those industries in his reading. There are as many romances in the utilization of waste as there are in the discovery of new mines. The advertisements offering to buy and sell various old metals and other materials indicate the wide field covered by the term "junk." Bones, old rope, old bags, burlap, old hats, leather shoes, bottles, broken glass, fur clippings are known components of the junk trade and are classified, sorted, and disposed of as readily as rags, rubber, and waste paper. The old pair of rubbers discarded may form a part of the next pair of rubber heels or door mat purchased. Rags thrown away are carefully sorted and are reasonably sure of returning to usefulness in the form of writing paper, roofing felt, wiping rags or waste for machinery, or as shoddy in clothing. It is undoubtedly true that most people know more about the sources of new products than they do about the varied and interesting uses of waste materials. If the public were better informed about the many industries partly or wholly dependent on junk and how the products of such plants were made more expensive because the raw material had not been properly selected and segregated greater interest would be taken in the national propaganda of conservation, and this publicity would lower living costs.

The National Association of Waste Material Dealers has succeeded in remedying many trade abuses and the metal division of the organization has grown until it includes practically every leading dealer in scrap metals and drosses. It has a grievance committee, composed of three, to whom all disputes between members are referred. If this committee is unable to adjust a dispute, it recommends arbitration. There have been disputes but all have been adjusted, and so far no member has entered suit against a fellow member.

## CLASSIFICATION FOR OLD METALS.

The following standard of classification for old metals has been adopted by the National Association of Waste Material Dealers to be effective from July 1, 1917, to July 1, 1918:

*Standard classification for old metals, effective July 1, 1917.*

| Code word. | |
|---|---|
| Area. | 1. Delivery: (*a*) Delivery of more or less on the specified quantity up to 2½ per cent is permissible.<br>(*b*) If the term "about" is used, it is understood that 5 per cent, more or less, of the quantity may be delivered.<br>(*c*) Should the seller fail to make deliveries as specified in the contract, the purchaser has the option of canceling all of the uncompleted deliveries or holding the seller for whatever damages the purchaser may sustain through failure to deliver, and if unable to agree on the amount of damages, the arbitration committee of the National Association of Waste Material Dealers, appointed for this purpose, to determine the amount of such damages.<br>(*d*) In the event that buyer should claim the goods delivered on a contract are not up to the proper standard, and the seller claims that they are a proper delivery, the dispute shall be referred to the arbitration committee of the National Association of Waste Material Dealers, to be appointed for that purpose.<br>(*e*) A contract for a carload, unless otherwise agreed upon, shall mean the minimum quantity recognized by the official classification tariff of the district in which the seller is located.<br>(*f*) A ton shall be understood to be 2,000 pounds, unless otherwise specified.<br>(*g*) If, through embargo, a delivery can not be made at the time specified, the contract shall remain valid, and shall be completed immediately on the lifting of the embargo, and terms of said contract shall not be changed. |
| Base. | 2. Heavy copper: This shall consist of copper not less than ⅛ inch thick, and may include trolley wire, heavy field wire, heavy armature wire that is not tangled, and also new copper clippings and punchings, untinned and clean, and copper segments that are clean. |
| Clan. | 3. No. 1 copper wire: To consist of clean untinned copper wire not smaller than No. 16 B. & S. wire gauge, to be free from copper wire which is brittle and all foreign substances. |
| Dale. | 4. No. 2 copper wire: To consist of miscellaneous clean copper wire such as of necessity would be taken out of the heavy copper and the No. 1 copper wire, but to be free of hair wire and burnt wire which is brittle. |
| Edge. | 5. Light copper shall consist of the bottoms of kettles and boilers, bathtub linings, hair wire, burnt copper wire which is brittle, roofing copper and similar copper, free from radiators, brass, lead, and solder connections, readily removable iron, old electrotype shells, and free of excessive paint, tar, and scale. |
| Face. | 6. Composition or red brass shall consist of red scrap brass, valves, machinery bearings, and other parts of machinery, including miscellaneous castings made of copper, tin, zinc, and / or lead, no piece to measure more than 12 inches over any one part, to be free of aluminum and manganese, also free of railroad boxes, cocks and faucets, gates, pot pieces, ingots, and burned brass. |
| Gage. | 7. Railroad bearing shall consist of railroad boxes or car-journal bearings, must be old standard used scrap, free of yellow boxes, plastic and similar bearings, also iron-backed boxes, and must be free of babbitt; also free of excessive grease and dirt. |
| Hive. | 8. Cocks and faucets: To be mixed red and yellow, free of gas cocks and beer faucets; shall be at least half red. |

Code word.

Iris. 9. Heavy yellow brass shall consist of heavy brass castings, rolled brass, rod brass ends, brass screws, and tinned or nickel-plated brass tubing; to be free of iron and dirt and must be in pieces not too large for crucibles; no piece to measure more than 12 inches over any one part. Must also be free of aluminum and manganese mixtures. Condenser tubes shall not be considered as heavy brass.

Jolt. 10. Light brass shall consist of light sheet brass, forks and spoons, miscellaneous brass that is too light for heavy, to be free of any visible iron, radiators, gun shells containing paper, ashes or iron, loaded lamp bases, and clockworks.

Lurk. 11. New brass clippings shall consist of the cuttings of new sheet brass, to be absolutely clean and free from any foreign substances.

Mint. 12. Brass tubing shall consist of brass tubing, free of nickel plating, tinned, soldered, or tubes with cast-brass connections. To be sound, clean tubes, free of sediment and condenser tubes.

Nook. 13. No. 1 composition turnings: To be free of aluminum, manganese, plastic, and yellow brass turnings, not to contain over 2 per cent iron, to be free of grindings or foreign material, especially babbitt, and free from adulterations made to resemble metal. Turnings not according to this specification subject to sample.

Oral. 14. No. 1 yellow brass turnings shall consist of strictly rod turnings, free of aluminum, manganese, composition, and tobin turnings. Not to contain over 3 per cent of iron, oil or other moisture, to be free of grindings and babbitts. To avoid dispute, to be sold subject to sample.

Pike. 15. No. 1 pewter shall consist of tableware and soda-fountain boxes, but in any case must test 84 per cent tin. Syphon tops to be treated for separately.

Quip. 16. Auto radiators: To be classed separately, must be free from iron.

Reef. 17. Zinc must consist of clean sheet and cast zinc, also cast batteries to be free of loose oxide and dross, salammoniac cans, and other foreign materials.

Skim. 18. Tin foil shall consist of pure foil, free of lead composition and other foreign ingredients and matters.

Tack. 19. Electrotype shells must be hand picked and free of dross.

Upas. 20. Battery lead plates shall consist of battery lead plates, free of wood, rubber, and paper.

Alum. 21. New sheet aluminum clippings shall consist of new sheet aluminum and cuttings. Must be free from oil, grease, and any other foreign substances. Must be guaranteed not less than 98 per cent pure aluminum.

Build. 22. Aluminum wire shall consist of aluminum wire guaranteed 98 to 99 per cent pure aluminum and must be free from corrosion and any other foreign substance.

Clean. 23. Painted sheet aluminum shall consist of painted sheet aluminum and must be absolutely free from iron, dirt, or any other foreign substance.

Dime. 24. Aluminum castings shall consist of aluminum castings, free from iron, babbitt, brass, and any other foreign substance. Must not exceed 2 per cent of oil and grease.

Elm. 25. Old sheet aluminum shall consist of old and manufactured sheet aluminum. Must be free from painted sheet aluminum, iron, dirt, and any other foreign substance.

Frank. 26. Aluminum borings: To avoid dispute, should be sold subject to sample.

Grew. 27. Aluminum foil shall consist of pure aluminum foil, free from paper and any foreign ingredients.

Halt. 28. Packages shall be good, strong packages, suitable for shipment, and each package to be plainly marked with the gross and tare weights so that when packages reach their destination their weights can be easily checked.

When goods are not packed according to the above specifications and shipper wants his rejections returned, the cost of labor shall be charged to the shipper.

## REVIEW OF THE SECONDARY METALS INDUSTRY IN 1916.

Dealers in and refiners and smelters of waste metals did a large and profitable business in 1916. Stocks of many new metals were small, and spot shipments frequently were not available. The scarcity and the high prices demanded for new pig metals stimulated the sale of scrap metal. Frequently higher prices were paid for prompt shipments of scrap metals than were obtained for new metals sold under contract. There was also a large increase in the sale of guaranteed composition ingots made from scrap.

The value of the secondary metals, exclusive of gold, silver, platinum, iron, steel, and ferroalloys, recovered in the United States increased from $114,304,930 in 1915 to $265,377,856 in 1916. The increase was partly due to larger use and partly to much higher average prices.

The value of the secondary platinum, iridium, and palladium recovered in 1916 amounted to about $4,000,000, and the value of old jewelry, dental waste, silver spoons, ornaments, and other material containing gold or silver, remelted and refined, was probably more than $20,000,000. It is difficult to estimate the value of ferrous scrap remelted in 1916. Some of the scrap ferrous metal contained nickel, tungsten, manganese, or other alloys, which made it many times more valuable than the more ordinary commercial products. Old rails, car wheels, pipe, and other iron and steel shapes, were often sold at prices in excess of the original cost. Iron and steel scrap is used by all foundries and rolling mills, and hundreds of thousands of tons are collected, sorted, and shipped. Prices for iron and steel scrap have increased to record figures. The value of all other waste materials has increased so greatly that the total value of waste metals and other junk was 100 per cent more in 1916 than in 1915.

It is impracticable and unnecessary to segregate the statistics relating to the melting, refining, and using of secondary metals according to States, but more than 90 per cent of the refining and smelting of drosses and scrap metals in the United States is confined to the territory east of St. Louis and north of Ohio River.

About 43 per cent of the secondary aluminum was reported from the States of Ohio and Michigan, 27 per cent from Illinois and Wisconsin, and 18 per cent from New York, New Jersey, and Massachusetts.

Smelters and refineries in St. Louis and Chicago recovered about 37 per cent of the antimony in alloys, and those in New York and Philadelphia about 45 per cent. The largest recoveries from tin dross, tin scruff, and clean tin scrap were made in Pennsylvania, New York, and New Jersey. Nearly all the secondary nickel was reported from Connecticut. The recoveries of lead, zinc, brass, and copper, and of such alloys as babbitt, bronze, and pewter, were more generally distributed. The greatest number of the larger smelters or refiners of secondary metals are located at or near New York, Philadelphia, Chicago, Pittsburgh, St. Louis, Detroit, Cincinnati, Cleveland, San Francisco, and Tottenville, N. Y., though there are many large and small plants at other places.

## SECONDARY METALS RECOVERED.

*Secondary metals recovered in the United States in 1915 and 1916.*

| | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| Secondary copper, including that in alloys other than brass | 99,937 | $33,498,882 | 140,000 | $68,880,000 |
| Remelted brass | 137,500 | 40,788,000 | 300,000 | 127,440,000 |
| Secondary lead | 36,400 | 7,416,600 | 56,700 | 13,289,400 |
| Recovered lead in alloys | 42,500 | | 39,600 | |
| Secondary spelter | 52,900 | 14,433,600 | 50,700 | 14,284,400 |
| Recovered zinc in alloys other than brass | 5,300 | | 2,600 | |
| Secondary tin | 5,250 | 10,554,180 | 7,600 | 15,131,040 |
| Recovered tin in alloys | 8,400 | | 9,800 | |
| Secondary antimony | 2 | 1,811,568 | 80 | 2,270,016 |
| Recovered antimony in alloys | 3,100 | | 4,400 | |
| Secondary aluminum | 5,700 | 5,802,100 | 12,900 | 23,430,200 |
| Recovered aluminum in alloys | 2,800 | | 6,400 | |
| Secondary nickel [a] | ..... | ..... | 16 | 652,800 |
| Recovered nickel in alloys [a] | ..... | ..... | 800 | |
| | ..... | 114,304,930 | ..... | 265,377,856 |

[a] Recoveries made by International Nickel Co. from scrap nickel or alloys and from nickel in scrap ferrous alloys from any source are not included.

## SECONDARY COPPER.

The total quantity of secondary copper recovered in 1916, on the assumption that the brass remelted had an average copper content of 70 per cent, was 350,000 tons, of which 52,212 tons (22,425 tons more than in 1915) was recovered by plants refining primary metals and the remainder by plants treating only secondary materials. The copper produced by smelters of the latter class includes 74,100 tons of pig copper, 14,000 tons of copper in alloys other than brass, and 210,000 tons of copper in remelted brass. These figures indicate an increase for 1916 of about 20,000 tons of pig copper, 113,750 tons of copper in brass, and a decrease of about 2,000 tons in alloys other than brass. At least 175,000 tons was recovered from clean scrap made in the course of manufacture of copper and brass ware, so that less than 175,000 tons was obtained from ashes, cinders, and scrap, or from material that had actually been used and discarded. From the reports received it is quite evident that there was an increase in the quantity of old scrap brass and copper smelted and that there was a very much larger proportionate increase in the quantity of clean new scrap remelted. The reports from rolling mills, munition factories, and other users of brass show enormous increases in the quantity of clean scrap remelted. The increase in the quantity of scrap brass used amounted to 162,000 tons, and of this increase at least 100,000 tons was clean new punchings, filings, and clippings. The decrease shown in the quantity of secondary copper in alloys other than brass was undoubtedly due to including alloys containing tin (which properly should be termed bronze) under the classification "brass."

The value of the copper, both as metal and in alloys, is computed at the average yearly price of 24.6 cents, the average sales price of all marketable grades of new metal.

According to the Bureau of Foreign and Domestic Commerce, the exports for the calendar year 1916 of scrap brass, fit only for remanufacture, were 3,478 tons and the imports of copper and brass scrap were 22,982 tons. Many railways sell or turn in the larger portion of their brass and copper scrap and other metal waste to dealers in part payment for new material, but the reports received show that the railways utilized in their own shops and foundries more than 14,000 tons of brass, in addition to 950 tons of copper and 3,000 tons of copper in alloys other than brass.

The production of copper from secondary sources in 1916 was equal to about 31 per cent of the refinery output of primary copper in the United States from all sources, or about 37 per cent of the primary copper smelted from domestic ore.

## SECONDARY LEAD.

The secondary lead recovered in 1916 amounted to 96,300 tons, or about 17,400 tons more than in 1915. The secondary lead recovered as pig lead increased about 20,300 tons, though the recovery of secondary pig lead made by those smelters whose product is mainly primary metal was only 3,129 tons more in 1916 than it was in 1915. A large portion of the recovered lead in alloys was derived from old babbitt, solder, type metals, and white metal drosses. The main sources of secondary pig lead are old pipe, lead cable, battery lead, and lead lining of acid tanks. Regular smelters reported the recovery of 14,694 tons of lead from scrap lead and scrap antimonial lead. The quantity of scrap antimonial lead remelted by regular smelters was nearly 48 per cent more than that reported in 1915.

The total output of secondary lead was equal to 16.8 per cent of the refined primary lead produced in the United States in 1916, compared with 14.3 per cent in 1915. It was exceeded by the primary domestic lead output of only three States—Missouri, Idaho, and Utah—and was more than the combined quantity of primary lead derived from the ores smelted from all other States.

## SECONDARY ZINC.

The output of secondary zinc (including that in brass) amounted to 115,000 tons and equaled 16 per cent of the production of primary spelter in the United States in 1916, compared with 19 per cent in 1915. The recovery was about 22,500 tons more than in 1915, all of which increase was owing to the increased quantity of zinc recovered in brass, for the recovery from zinc dross and skimmings was less in 1916 than in 1915.

Two smelters in New Jersey, two in New York, and one each in California and Pennsylvania, which treat only zinc drosses and skimmings, use large graphite retorts of 600 to 800 pounds capacity instead of the small clay retorts used by smelters treating ore or mixed ore and drosses. The many uses of zinc drosses and skimmings create active competition for their purchase. Considerable zinc is recovered by sweating, and the residues are sold for redistillation. Secondary spelter varies in quality just as the spelter derived from

ore does, but a part of the secondary spelter is reported to be of excellent quality.

The production of spelter from drosses and skimmings made by those zinc smelters which do not treat any ore was 2,800 tons less in 1916 than in 1915. This decrease was partly due to the redistillation of the low grades of spelter in order to meet the demand for spelter suitable for brass used in making war munitions. The main reason, however, was that there was a decrease of about 97,000 tons in the quantity of galvanized sheets, pipes, and forms produced, so that less zinc dross was shipped by galvanizing plants.

The zinc recovered in alloys other than brass amounted to 2,600 tons, compared with 5,300 tons in 1915. Of the 50,700 tons of secondary zinc recovered as spelter 29,663 tons were obtained by redistillation from drosses and skimmings and from scrap zinc treated by the electrolytic process. Of this quantity 16,196 tons were obtained by smelters whose principal source of zinc is ore. This was about 1,300 tons more than the recovery from drosses and skimmings in 1915. In addition to the 50,700 tons of remelted and redistilled spelter it is estimated that at least 15,000 tons of zinc chloride was made, and likewise about 51,291 tons (marketed production) of the zinc pigment lithopone (containing approximately 32 per cent zinc sulphide and oxide). The zinc used in both of the last-named products is derived almost altogether from zinc drosses and skimmings. The exports of zinc drosses, which amounted to 2,526 tons in 1914 and to 3,668 tons in 1915, decreased to 48 tons in 1916.

## SECONDARY ANTIMONY.

The production of secondary antimony, of which all but 80 tons was recovered in alloys, increased from 3,102 short tons in 1915 to 4,480 tons in 1916. The value assigned is arbitrary and is based on the average yearly price for ordinary brands of antimony published by the American Metal Market. The regular smelters reported the recovery of 528 tons of antimony contained in antimonial lead scrap, an increase of 52 tons. The principal materials refined or remelted which contained antimony as an alloy were hard lead drosses, babbitt, solder, pewter, and type metal. The imports in 1916 of antimony as metal in ore or as oxide or salts amounted to 11,928 tons, and the recovery from secondary sources was equal to 38 per cent of the imports. The production of antimony from antimony and antimoniacal lead ores of domestic origin in 1916 was about 4,500 tons, or about the same quantity as that recovered from secondary sources.

## SECONDARY TIN.

Although the United States consumes nearly 50 per cent of the world's production of tin, apparently there were no domestic tin ores smelted in the United States in 1916, though some tin concentrates, containing about 140 tons of metallic tin, were shipped from Nome, Alaska, to Singapore, Federated Malay States, for treatment. A new tin smelter having a capacity of 18,000 tons a year was put in operation in March, 1916, by the American Smelting & Refining

Co., in New Jersey, and tin concentrates from Bolivia were imported and smelted.

Another tin smelter is to be built on Long Island by the Williams-Harvey Corporation, which will also use Bolivian ores.

The secondary tin recovered in 1916 was equal to about 24 per cent of the tin imported, as metal or as oxide, into the United States during the year (69,055 short tons). Secondary tin recoveries increased from 13,650 tons, valued at $10,554,180, in 1915, to 17,400 tons, valued at $15,131,040, in 1916. The quantity recovered as tin was 7,600 tons and that in alloys and chemical compounds 9,800 tons. The value of the recovered tin here assigned is arbitrary and is based on the yearly average price for new metal given by the American Metal Market. The secondary tin in alloys increased about 1,400 tons and the secondary pig tin about 2,350 tons.

Nearly all clean tin-plate scrap is detinned by one of three processes—the electrolytic alkali, the chlorine, or the alkali saltpeter.[1]

By the first method the tin is recovered in the form of a spongy granulated precipitate which can be remelted into pig tin; by the second process tetrachloride of tin is recovered for use in silk dyeing and weighting; and by the third process the tin is recovered as an oxide which is either used as coloring in the enamel industry or is smelted into pig tin by means of a reverberatory furnace.

The recovered tin in alloys includes the tin content of products made in several plants from clean tin-plate scrap and a small quantity of old tin cans. This included some tin oxide and putty powder but consisted mainly of tin chloride. The production of these compounds is calculated as metal and not separately stated in order to avoid disclosing confidential information. As the products are made from scrap tin and thus conserve the primary metal, they are properly regarded as recovered tin.

The largest recoveries of tin were made from the scruff and drosses that occur in making tin plate and terneplate, and amounted to more than 4,850 tons. The quantity of tin plate made in 1916 was about 200,000 tons more than in 1915, and the quantity of tin recovered from scruff and drosses increased more than 1,000 tons.

About 2,600 tons of tin were recovered from clean scrap tin plate, either as pig tin or as tin chloride or tin oxide. Apparently only about 750 tons of pig tin were recovered from scrap-tin (not tin-plate) clippings, old tin pipe, and tin foil, and it is impossible to give the separate quantities of tin recovered from these sources.

Only one plant reported using solely old tin containers, from which the tin coating and solder were first sweated and the black plate was then remelted to make sash weights. The tin scrap and old tin cans are used in the western mining regions for their iron content for the precipitation of copper from mine waters.

An increased quantity of tin was recovered in bronze, and a considerable part of the brass remelted contains a small quantity of tin and of lead. Other alloys from which secondary tin was recovered were solder, babbitt, pewter, terne metal, and electrotype metal.

The Mining Magazine of London, England, states that many announcements have been made of schemes to utilize old tin cans.

[1] A short history of the detinning industry: Met. and Chem. Eng., August, 1917, pp. 187–189.

The following article is taken from the weekly bulletin of the Canadian Department of Trade and Commerce of June 11, 1917:

*Utilizing empty cans in England.*[1]—The municipality of Hornsey, England, under the direction of the borough engineer and surveyor, Mr. E. J. Lovegrove, has devised a practicable and profitable method of utilizing the empty tins that form a part of the refuse brought to the dust destructor. An important advantage of the process seems to be that it can be carried on with very little additional expense by municipalities that maintain an incinerator for the destruction of waste material. Its chief feature is a special furnace for the treatment of waste tin by gases, which can be added to the existing plant and worked in conjunction therewith, with only a trifling additional outlay in fuel and labor.

Mr. Lovegrove states that while "detinning," "desoldering," and "baling" are not new, the novelty in the process adopted in the district of Hornsey is that the detinning—that is, burning the tin off the steel—is done by means of heat from waste flue gases on their passage from the furnace to the chimney, thereby reducing the cost of a separate and specially fired furnace. As adopted by the Hornsey town council the process involved only a comparatively nominal capital outlay (under £200), the hydraulic pressure being already installed at the works in connection with other machinery.

The process is protected by patent in England, and rights are being taken out for foreign countries. * * *

The following memorandum on the utilization of empty cans has been received from Mr. Lovegrove:

"In order to describe the process, it will be convenient to deal with a typical case of 100,000 population. The quantity of scrap collected from the house refuse at the furnaces, which must necessarily vary according to the class of town and population, is about 200 tons per annum, which may be divided approximately as follows: Tin, 135 tons; light scrap, 30 tons; galvanized scrap, 25 tons; enamel scrap, 10 tons; total, 200 tons.

"It is not attempted, for a small unit, to recover the tin, as the process has not, to the writer's knowledge, yet been found commercially possible. The cans are therefore detinned by heat. In this district they are sorted out on the top of the delivery platform and dropped into a furnace, through which the flue gases are allowed to pass. The heat melts off the solder, which falls into a collecting trough. The cans are then removed and put through a hydraulic press and formed into bales about 2 feet 3 inches by 15 inches and about 4 inches deep. When removed no banding is necessary, as the bales hold together in such a way that they can be put into a lorry and thence taken to railway trucks for delivery to the steel works. The solder that is collected in the trough has necessarily a certain quantity of dross in it, from which it has to be separated to find a ready market. The light scrap is merely sorted out and baled without treatment of any kind and similarly forwarded to the steel works. The galvanized scrap is baled without treatment and delivered to degalvanizing works. The enamel scrap has to be specially treated by firms dealing in such material, who remove the enamel and recover the steel.

"Dealt with in this way, the recovered metal produces a revenue in this district of upward of £200, thus doing away with the necessity of paying for the cartage of material to waste tips, which still obtains in many districts. The plant installed at Hornsey, by the adoption of the above-mentioned furnace in connection with the destructor plant, has rendered possible the carrying out of the work as part of the depot routine, no additional labor having been employed. The prices obtained, however, are somewhat low on account of the distance of the town to the nearest steel works—say, about 200 miles—so that towns more fortunately situated would obtain a larger revenue. It will be noted that the flue gases from a dust destructor are used, but the same principle may be applied to the waste gases from any furnace, boiler, or the like at works where there is a large output of waste cans to be dealt with."

*Continuous detinner.*—The following is a brief description of a new detinning process.[2]

J. H. Hall, managing director of the Monometer Manufacturing Co., of Aston, Birmingham, England, has invented a machine for

[1] Weekly Bulletin, Canadian Department of Trade and Commerce, Ottawa, June 11.
[2] Daily Metal Reporter, Mar. 5, 1917.

recovering tin and solder from old cans and scrap. It consists of an inclined cylinder which rotates within an outer cylinder lined with firebrick. The inner cylinder has at its higher end a feed aperture which once in every revolution registers with a stationary hopper, through which the tins to be treated are fed in. It is heated by a series of gas or oil burners so arranged that the temperature gradually increases from the upper to the lower or outlet end.

The cans fed in by the hopper slowly gravitate down the heating chamber as it rotates, until finally they are discharged by a chute, while the molten tin and solder are collected by channels formed in the interior of the chamber, and pass out by a second smaller chute. The machine is thus continuous in operation.

It is not probable that any appreciable quantity of old tin cans has been treated in Great Britain and the recovery of tin from such sources in 1916 was small.

The high prices now prevailing in the United States for pig tin and also for steel scrap have resulted in a number of inquiries to the Geological Survey as to whether old tin plated food containers could be profitably treated. The Survey has not been able to assure would-be investors that such an undertaking would be profitable. The coating of tin on the steel sheet is thin, and usually the tins are partly rusted and retain some of the food contents. The treatment of such containers would result in the recovery of considerably less than 1 per cent of the weight of the cans in low-grade tin. The scrap sheet steel refuse can not be freed from all the tin and solder. The scrap is thin and light, which necessitates handling a large volume of material to get car shipments, and aside from the undesirable alloys of tin and lead the losses in melting such scrap are large. The only purchasers of this kind of steel scrap are the manufacturers of sash weights; occasionally there is a demand from foundries that have orders for very rough castings, in which a portion of burned steel cans can be mixed with cast-iron scrap. The market in all cases is very limited, and notwithstanding the very high prices of desirable grades of scrap iron and steel the old scrap cans would probably not be worth more than $6 to $8 a ton delivered to the consumer.

The general opinion of waste metal dealers is that the secondary recoveries of tin will not materially increase. There can be and probably will be some saving effected by using less tin in alloys, such as babbitt, brass, and bronze and by the return and reuse of large cans supplied to domestic buyers of petroleum products; but any large saving of tin must be effected by marketing many commodities in containers not requiring the use of tin plate. Tin boxes or tin foil make the best packages for tobacco, cigarettes, candies, and many other articles; but tobacco can be packed for domestic use in paper or fabric containers; tooth powder can be sold in paper boxes; and liquid dentifrices and many other druggists' supplies can be sold in porcelain or glass jars instead of in collapsible tubes. William Crawford Hirsch, editor of the Waste Trade Journal, states that one of the largest candy factories in the United States, which formerly sold 50 per cent of its output in tin boxes, is now using waxed paper and paper boxes for its products.

## SECONDARY ALUMINUM.

The recovery of secondary aluminum as pig aluminum or in alloys in 1916 amounted to 19,300 tons, valued at $23,430,200, as compared with 8,500 tons, valued at $5,802,100, in 1915. The quantity recovered in alloys amounted to 6,400 tons.

The increase in quantity of secondary aluminum in 1916 was partly due to the material increase of castings used in automobiles. The high prices prevailing also no doubt resulted in considerable aluminum wire being remelted.

Various products are made by smelters and refiners from scrap aluminum. One sample of pig aluminum which was made from clean sheet-aluminum clippings showed the following analysis:

*Analysis of secondary aluminum.*

| | |
|---|---|
| Aluminum | 98.75 |
| Copper | .16 |
| Silica | .11 |
| Iron | .56 |
| Manganese | .42 |
| | 100.00 |

The standard No. 12 alloy is the best known and most widely used of aluminum casting alloys. It contains a minimum of 92 per cent aluminum and from 7 to 8 per cent copper. Another alloy made by a large secondary aluminum smelter contains 4 per cent zinc, 8 per cent copper, and the remainder aluminum. Some of the reasons for defective aluminum castings are given by L. M. Brile.[1]

Aluminum chips from castings used in the manufacture of automobiles have become a large source of secondary aluminum. By the old methods of treatment the loss in remelting such chips was sometimes as much as 40 per cent. A publication issued by the United States Bureau of Mines[2] gives an account of experiments which resulted in reducing such losses to as little as 10 per cent.

## SECONDARY NICKEL.

For the first time an effort was made in 1916 to ascertain the quantity of secondary nickel recovered as nickel or in alloys. The reports received showed that 816 tons of nickel were recovered, a considerable part of which was from clean new scrap. This does not include any nickel in scrap ferrous alloys nor the recoveries from secondary sources made by the International Nickel Co. The scrap remelted by the International Nickel Co. is included with matte and ore, and no separate recovery is attempted. The quantity of nickel in matte and in ore imported into the United States in 1916 was 72,611,492 pounds, most of which was from the Sudbury district, in Ontario. No direct production of nickel from American nickel ores is known to have been made in the United States in recent years, but an equivalent of 918 short tons of nickel was saved in 1916 as a by-product in the electrolytic refining of copper.

[1] Metal Industry, February, 1916, pp. 86–87.

[2] Gillett, H. W., and James, G. M., Melting aluminum chips: Bur. Mines Bull. 108, 1916.

As the greatest use for nickel is as an alloy in steel, and the secondary recoveries of nickel reported to the Survey in 1916 were solely from nonferrous scrap, it is evident that the 816 tons of nickel reported form a small portion only of the nickel in alloys recovered and reused. The secondary nickel reported in 1916 was nearly all recovered from old nickel anodes, German silver, and monel metal. Analyses of various nickel alloys have been published by the United States Geological Survey.[1]

[1] Hess, F. L., Nickel: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, pp. 763–765, 1917.

# SILVER, COPPER, LEAD, AND ZINC IN THE CENTRAL STATES.

(MINES REPORT.)

By J. P. DUNLOP and B. S. BUTLER.

## INTRODUCTION.

By J. P. DUNLOP.

The following is an account of the production of silver, copper, lead, and zinc in 1916 by the mines of the Central States, including Arkansas, Illinois, Kansas, Kentucky, Michigan, Missouri, Oklahoma, and Wisconsin. The territory thus embraced lies in the great interior valley province of the United States which extends from the Appalachian system to the Rocky Mountain front, excluding the Black Hills. Most of the mines are developed in the Paleozoic sedimentary rocks of this province, but the copper range of northern Michigan comprises lavas and intercalated sediments of pre-Cambrian age.

The statistics of production in these States have been compiled by the United States Geological Survey from confidential reports by each mine in operation and represent the quantity of metals recovered or paid for in the ore that was treated or sold during the year.

The method of marketing and recording the mine output in the lead and zinc regions of the United States differs from that employed in the Western States. In the Western States the miner usually sells his ore according to the assay content of metal at a certain price per unit. In the lead and zinc regions of the Central States, however, where the material sold is principally concentrates,[1] payment is made according to a basis price for a certain quality of concentrates. The details of this method are given in the pages devoted to Missouri in this report for 1914. The figures reported to the Survey by producers represent the quantity and assay content of concentrates sold and the amount received in payment. The total metal produced is calculated from the first two of these items.

The operators in Michigan report the quantity of concentrates produced and the actual recovery of copper from concentrates smelted.

In any year the mines may produce more or less concentrates than are smelted during the same period. The copper content of concentrates produced during the year but not smelted has been estimated on the basis of the average copper recovery per ton for the year of the company producing it.

[1] In local usage the ore as mined is called "dirt" and the concentrates are classed as "ore." Where the capacity of a concentrating plant is given, such capacity is to be understood as based on a 10-hour shift unless otherwise stated.

## TENOR OF LEAD AND ZINC ORES OF THE CENTRAL STATES.

Much of the ore mined in the Western States is crude smelting ore; that is, it can be smelted directly without preliminary concentration. All but a very small portion of the ore from the Central States is of such tenor that it requires concentration. The only fair basis for comparison of the relative magnitude of mining operations in different States is that of quantity of crude ore, or "dirt," as it is usually called in the lead and zinc regions of the Central States. In the Joplin and upper Mississippi Valley regions the number of cans of ore hoisted is usually recorded and the approximate weight of the cans is generally known. Thus each company knows, in a general way, about what percentage of concentrates the run of mine is yielding. Knowing the total production of concentrates and the average yield of concentrates from crude ores, one can arrive at a close estimate of the crude ore raised. Only the actual operating companies have the data, however, and it was the practice of the Survey, in order to shorten the list of producers as much as possible, to send requests only to the owners of the mining land or the companies holding first leases and to depend upon them to report the whole production of the tract. Since 1911 not only the first lessees of the land have reported to the Survey, but also most of the sublessees have given data regarding both concentrates produced and "dirt" or ore milled. The tables of tenor of ore which follow in the sections devoted to the respective States show the comparative percentages for the last three years.

In Kentucky and southern Illinois the lead and zinc concentrates are recovered as by-products in the concentration of the fluorspar which they accompany, and it was not possible to make calculations of the metal content of the crude ore raised.

*Tenor of copper, lead, and zinc ores of Central States, 1914-1916.*

| State. | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|
| | Crude ore. | Metal content.[a] | Crude ore. | Metal content.[a] | Crude ore. | Metal content.[a] |
| | *Short tons.* | *Per cent.* | *Short tons.* | *Per cent.* | *Short tons.* | *Per cent.* |
| Arkansas | 20,000 | 4.10 | 110,000 | 3.31 | 249,000 | 3.15 |
| Illinois (northern) | 261,300 | 2.49 | 316,000 | 2.35 | 288,100 | 1.60 |
| Kansas | 540,500 | 2.58 | 709,400 | 2.42 | 774,400 | 1.98 |
| Michigan | 9,269,413 | .89 | 12,334,700 | 1.07 | 12,364,114 | 1.08 |
| Missouri | [b]11,492,300 | 2.70 | [b]15,573,700 | 2.32 | [b]18,664,024 | 2.18 |
| Oklahoma | 763,920 | 3.02 | 891,800 | 2.68 | 1,406,900 | 3.13 |
| Wisconsin | 1,387,490 | 2.91 | 1,934,000 | 2.77 | 3,066,500 | 2.36 |
| | 23,734,923 | ..... | 31,869,600 | ..... | 36,813,038 | ..... |

[a] The percentages given in this column represent the metal content of the ore in so far as it is recovered in the concentrates. In Michigan the metal so recovered is copper, in the other Central States the metals are lead and zinc, the relative proportions of which are shown in the table on another page and in the tables of tenor of ore given in the sections devoted to the respective States.

[b] A small quantity of copper ore included.

This table shows that from the silver, copper, lead, and zinc mines of the Central States an increase of about 5,000,000 short tons of ore was treated in 1916, following an increase of 8,135,000 tons in 1915. The production of ore from the copper mines of Michigan

increased only 30,000 tons, but the production of ore in Missouri increased more than 3,000,000 tons, of which increase 2,000,000 tons was due to the "sheet ground" mines. The mines of the disseminated lead district in southeastern Missouri increased their output about 400,000 tons. The only one of the Central States which had a decreased output of lead and zinc ore in 1916 was Illinois. The increases in 1916 in the other States were as follows: Arkansas, 126 per cent; Wisconsin, 59 per cent; Oklahoma, 58 per cent; and Kansas, 9 per cent.

The quantity of ore mined and treated from copper, lead, zinc, and lead-zinc mines in the Central States in 1916 was approximately 65 per cent of the total ore of that description sold or treated by mines in the United States in 1915 and was 28 per cent of all the metallic ores from domestic mines sold or treated in 1915.

The low average tenor of the metal content of all crude ore mined in the Central States in 1916 is best shown by the fact that the average value of the total recoverable metal content was only $4.72 per ton of crude ore treated, and this value is $0.92 more than it was in 1915. The 24,448,800 tons of zinc, lead, and lead-zinc ores treated in the Central States in 1916 yielded lead and zinc concentrates which sold for $65,381,508, so that the mine operators realized an average of $2.68 a ton of ore mined and treated, against $2.33 a ton of ore realized in 1915. This increase of 15 per cent does not represent the entire gain, for in many cases the prices paid for ore made possible the mining of ores that could not possibly have been mined profitably under normal conditions. The increased value of the zinc concentrates in 1916 on the whole probably did not result in profits equal to those accruing in 1915, on account of the large increase in the cost of labor, powder, fuel, and other supplies.

## PRODUCTION.

The total value of the mine production of silver, copper, lead, and zinc in the Central States in 1916 was $173,778,990, an increase of $52,495,728, or 43 per cent, compared with the value for 1915. The total value of the production of these metals for the years 1907 to 1916, inclusive, was $813,329,801, of which $352,313,421 was for copper, $278,525,338 for zinc, $179,764,792 for lead, and $2,726,250 for silver. In only 1915 and 1916 has the value of the recoverable zinc exceeded that of copper.

### SILVER.

The production of silver in the Central States in 1916 was 852,380 fine ounces, which, at the average price of 65.8 cents per fine ounce (15.1 cents higher than in 1915), was valued at $560,866, as compared with 647,553 fine ounces, valued at $328,309, in 1915. Nearly all the silver that is produced in the Central States is recovered incidentally in the production of other metals. Of this production 716,640 ounces came from the copper lodes of Michigan, an increase of 130,707 ounces resulting from a larger copper output. About 28 per cent of the concentrates from lead ores mined in southeastern Missouri was desilverized and yielded nearly all the silver from that State recovered in 1916. A small output of silver was also derived

from copper ore, and the total recovery from Missouri amounted to 129,450 ounces, an increase of 71,694 ounces.

The lead-zinc-fluorspar deposits of the Kentucky-Illinois field also carry silver, and from the lead concentrates derived from Illinois 5,684 ounces of silver were recovered, an increase of 1,820 ounces.

## COPPER.

The mine production of copper in the Central States in 1916 was from Michigan and Missouri, the first-named State, as in other years, contributing nearly the entire output, which amounted to 274,078,725 pounds. The copper production of Michigan in 1916 was 273,692,525 pounds, which, at the average New York price of 24.6 cents a pound, was valued at $67,328,361, as against a yield of 265,283,378 pounds, valued at $46,424,591, in 1915. The copper produced in Missouri in 1916, amounting to 386,200 pounds, valued at $95,005, was derived mainly from concentrates recovered in dressing the lead ores of southeastern Missouri, but part came from ore carrying copper and silver, which was shipped from the Swansea mine in Ste. Genevieve County and the Racola mine in Washington County.

The total mine production of copper from Michigan and Missouri in 1916 was 8,393,187 pounds more than in 1915, and was 39,400,000 pounds more than the output of any other year since 1907, when these figures were first compiled.

## LEAD.

The mine production of lead in the Central States in 1916 was 251,405 short tons, which, rated at the average New York price for the metal for the year of 6.9 cents a pound ($138 a ton), was valued at $34,693,890, as compared with 222,548 short tons, valued at $20,919,512, in 1915. The output of lead increased 28,857 tons in 1916, and the value increased $13,774,378. In 1916 Missouri produced 92 per cent of the yield of lead in the Central States, and the recoverable lead content of galena and lead carbonate concentrates mined in Missouri in 1916 equaled 39 per cent of the refined primary lead recovered in the United States from domestic ore. Of the total output of lead in Missouri the "disseminated lead" district of southeastern Missouri produced 201,632 tons, an increase of 18,178 tons, again exceeding the yield from the Coeur d'Alene district of Idaho and retaining first place in production of lead in the United States. Southwestern Missouri was the next largest producing district in the Central States, with an output of 31,456 tons, or 4,922 tons more than in 1915. The increase in this district was mainly due to the increased mining of "sheet ground," as the production from the "soft ground" and shallow mines was only 600 tons more than in 1915. The Oklahoma production increased from 7,306 tons in 1915 to 12,115 tons in 1916, and the output of the Miami district in 1917 will probably exceed that of all regions other than southeastern Missouri.

The output of lead in 1916 from mines in Kentucky decreased and that from mines in Arkansas, Illinois, Wisconsin, and Kansas was considerably greater than it was in 1915. The total lead production from mines in the southern Illinois-Kentucky region, Arkansas and Kansas, and the Upper Mississippi Valley region, amounted to only 3 per cent of the output of the Central States.

## ZINC.

The production of zinc in the Central States in 1916, based on mine returns with a deduction for separating and smelting losses, was 265,301 short tons, valued at $71,100,868. The value is computed at 13.4 cents per pound of (spelter $268 per ton), the average sales price reported by the smelters for all grades of the metal.

The output in 1916 is the largest recorded yield from mines in the Central States, exceeding that of the year 1912 by 76,994 tons in quantity and by more than $44,000,000 in value, and the production of 1915 by 49,412 tons in quantity and $17,560,396 in value. The production of spelter in the Central States was about 47 per cent of the total production of primary spelter from domestic ores in the United States in 1916, or the same as in 1915.

The State of Missouri, with an increase in output of 19,660 tons, was again in 1916 much the largest producer of zinc in the United States. Its production was 155,960 tons, against 105,994 tons in 1914 and 136,300 tons in 1915. Wisconsin produced 56,803 tons in 1916, against 41,403 tons in 1915. Arkansas increased in output from 3,209 tons to 6,815 tons, Kentucky from 764 tons to 1,096 tons, Oklahoma from 14,314 tons in 1915 to 28,754 tons in 1916, or more than 100 per cent.

The Central States which had a decreased output of zinc were Kansas, which decreased from 14,365 tons in 1915 to 12,448 tons in 1916, and Illinois which decreased from 5,534 tons in 1915 to 3,404 tons in 1916.

### SUMMARY OF PRODUCTION BY STATES.

*Mine production of silver, copper, lead, and zinc in the Central States in 1916.*

| State. | Silver. | | Copper. | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| | *Fine ounces.* | | *Pounds.* | |
| Illinois | 5,684 | $3,740 | | |
| Michigan | 716,640 | 471,549 | 273,692,525 | $67,328,361 |
| Missouri | 129,450 | 85,178 | 386,200 | 95,005 |
| Oklahoma | 606 | 399 | | |
| Total, 1915 | 852,380 | 560,866 | 274,078,725 | 67,423,366 |
| | 647,553 | 328,309 | 265,685,538 | 46,494,969 |

| State. | Lead. | | Zinc. | | Total value. |
|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | |
| | *Short tons.* | | *Short tons.* | | |
| Arkansas | 272 | $37,536 | 6,815 | $1,826,420 | $1,863,956 |
| Illinois | 1,072 | 147,936 | 3,404 | 912,272 | 1,063,948 |
| Iowa | 14 | 1,932 | 21 | 5,628 | 7,560 |
| Kansas | 1,648 | 227,424 | 12,448 | 3,336,064 | 3,563,488 |
| Kentucky | 153 | 21,114 | 1,096 | 293,728 | 314,842 |
| Michigan | | | | | 67,799,910 |
| Missouri | 233,088 | 32,166,144 | 155,960 | 41,797,280 | 74,143,607 |
| Oklahoma | 12,115 | 1,671,870 | 28,754 | 7,706,272 | 9,378,541 |
| Wisconsin | 3,043 | 419,934 | 56,803 | 15,223,204 | 15,643,138 |
| Total, 1915 | 251,405 | 34,693,890 | 265,301 | 71,100,868 | 173,778,990 |
| | 222,548 | 20,919,512 | 215,889 | 53,540,472 | 121,283,262 |

## LEAD AND ZINC PRODUCTION, BY REGIONS.

The productive lead and zinc territory in the Central States naturally falls into seven regions, three of which are not limited to any single State. For statistical purposes the tables showing the production of lead and zinc by States are necessary and are so given. For practical purposes, however, it is desirable to compile the production by the natural regions irrespective of State lines.

The seven regions are as follows, in order of importance of output: (1) The Joplin region, comprising the district in southwestern Missouri, southeastern Kansas, and northeastern Oklahoma; (2) southeastern Missouri, containing the great disseminated lead deposits; (3) the upper Mississippi Valley region, including all the lead and zinc mines in southwestern Wisconsin, Iowa, and northwestern Illinois; (4) northern Arkansas; (5) the Kentucky-Illinois fluorspar region in southern Illinois and northern Kentucky; (6) central Missouri; (7) the Arbuckle Mountain region in southern Oklahoma.

The southeastern Missouri region produced about 80 per cent of the lead output of the Central States and about 34 per cent of the production of primary lead recovered from domestic ore smelted or refined in the United States in 1916. The Joplin region produced 18 per cent of the lead and 74 per cent of the zinc of the Central States in 1916, and was much the largest producer of zinc in the United States, yielding about 35 per cent of the total spelter production from domestic ores in 1916, as against 36 per cent in 1915. The upper Mississippi Valley region produced a little more than 1 per cent of the lead and more than 22 per cent of the zinc in the Central States in 1916. The production of zinc in the northern Arkansas region showed a substantial increase and amounted to about 2.5 per cent of that of the Central States in 1916.

The lower zinc content of the zinc concentrates produced in the upper Mississippi Valley region is clearly indicated by the fact that notwithstanding that the mines in the region yielded 35 per cent of the total output of zinc concentrates of all classes the recoverable zinc content of such concentrates was only about 22 per cent of the recoverable zinc from mines in the Central States.

*Mine production of lead and zinc in the Central States in 1916.*

| Region. | Concentrates. | | | | Total value of concentrates. |
|---|---|---|---|---|---|
| | Lead.[a] | | Zinc.[b] | | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | |
| Joplin | 58,405 | $4,898,120 | 382,242 | $30,123,296 | $35,021,416 |
| Southeastern Missouri[c] | 307,025 | 20,720,737 | 1,395 | 56,529 | 20,777,266 |
| Upper Mississippi Valley[d] | 4,883 | 339,750 | 220,777 | 7,927,748 | 8,267,498 |
| Northern Arkansas | 339 | 28,097 | 18,279 | 1,052,950 | 1,081,047 |
| Kentucky-southern Illinois | 1,101 | 83,619 | 3,048 | 133,282 | 216,901 |
| Arbuckle Mountain, Okla. | ..... | ..... | 348 | 17,380 | 17,380 |
| Total, 1915 | 371,753 | 26,070,323 | 626,089 | 39,311,185 | 65,381,508 |
| | 328,398 | 15,424,244 | 495,663 | 30,157,854 | 45,582,098 |

[a] Includes both galena and lead carbonate concentrates.
[b] Includes sphalerite, zinc carbonate, and zinc silicate concentrates.
[c] Owing to the small output from the central Missouri region it has in this report, for convenience, been included in the southeastern Missouri region.
[d] Includes Iowa, northern Illinois, and Wisconsin.

*Mine production of lead and zinc in the Central States in 1916*—Continued.

| Region. | Metal. | | | | Total value of metal. |
|---|---|---|---|---|---|
| | Lead. | | Zinc. | | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | |
| Joplin | 45,219 | $6,240,222 | 196,596 | $52,687,728 | $58,927,950 |
| Southeastern Missouri[a] | 201,632 | 27,825,216 | 433 | 116,044 | 27,941,260 |
| Upper Mississippi Valley[b] | 3,519 | 485,622 | 60,228 | 16,141,104 | 16,626,726 |
| Northern Arkansas | 272 | 37,536 | 6,815 | 1,826,420 | 1,863,956 |
| Kentucky-southern Illinois | 763 | 105,294 | 1,096 | 293,728 | 399,022 |
| Arbuckle Mountain, Okla. | ..... | ..... | 133 | 35,844 | 35,844 |
| Total, 1915 | 251,405 | 34,693,890 | 265,301 | 71,100,868 | 105,794,758 |
| | 222,548 | 20,919,512 | 215,889 | 53,540,472 | 74,459,984 |

[a] Owing to the small output from the central Missouri region it has in this report, for convenience, been included in the southeastern Missouri region.
[b] Includes Iowa, northern Illinois, and Wisconsin.

The volume of Mineral Resources for 1914 contains brief reviews of the history of lead and zinc mining in the Central States, the yearly production of each State for the period 1907 to 1914, inclusive, and historical notes and estimates of the total production of lead and zinc produced in each State before 1907. The separate chapter entitled "Silver, copper, lead, and zinc in the Central States in 1914" can be obtained on application to the Director, United States Geological Survey, Washington, D. C.

## ARKANSAS.

By J. P. Dunlop.

### PRODUCTION.

The value of the recoverable lead and zinc from Arkansas mines, which had increased from $65,214 in 1914 to $801,754 in 1915, was $1,863,956 in 1916. This was a larger proportionate increase than in any other Central State. The shipments of zinc carbonate and silicate were exceeded only by those of Missouri, and the development work done indicates that the Arkansas output of this class of zinc ores will continue to increase in 1917.

The production of galena and of sphalerite increased considerably, though the total yield of these ores was small as compared with that of other regions. The shipments of zinc carbonate and zinc silicate concentrates in 1916 were more than double those of 1915 and 4,000 tons more than the output for the period 1907 to 1915, inclusive. It is not improbable that the production of zinc carbonate and silicate concentrates in 1917 will be equal to or greater than the production from Missouri mines.

*Mine production of lead and zinc in Arkansas, 1907–1916.*[a]

| Year. | Ores. | | | | | | Metal content. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lead concentrates (galena). | | Zinc concentrates. | | | | Lead. | | Zinc. | |
| | | | Sphalerite. | | Silicate and carbonate. | | | | | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| 1916 | 339 | $28,097 | 1,670 | $112,726 | 16,609 | $940,224 | 272 | $37,536 | 6,815 | $1,926,420 |
| 1915 | 79 | 4,961 | 606 | 41,341 | 7,925 | 408,079 | 63 | 5,922 | 3,209 | 795,832 |
| 1914 | 52 | 2,408 | 743 | 19,406 | 1,143 | 25,187 | 41 | 3,198 | 608 | 62,016 |
| 1913 | 23 | 1,179 | 594 | 16,916 | 680 | 15,050 | 18 | 1,584 | 478 | 53,536 |
| 1912 | 39 | 2,180 | 1,419 | 56,235 | 462 | 11,231 | 31 | 2,790 | 748 | 103,224 |
| 1911 | 80 | 4,321 | 1,407 | 40,425 | 183 | 4,239 | 64 | 5,760 | 664 | 75,696 |
| 1910 | 80 | 3,714 | 1,857 | 74,136 | 128 | 2,641 | 63 | 5,544 | 994 | 107,352 |
| 1909 | 30 | 1,800 | 896 | 33,948 | 98 | 2,736 | 24 | 2,064 | 510 | 55,080 |
| 1908 | 18 | 985 | 516 | 18,270 | 939 | 21,469 | 15 | 1,260 | 605 | 56,870 |
| 1907 | 15 | 800 | 538 | 15,233 | 663 | 16,210 | 12 | 1,272 | 474 | 55,932 |

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses in zinc but not in lead. In comparing the values of ore and of metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily spot quotations at New York and the value of the zinc from the average sales price of all grades reported by the smelters.

*Tenor of lead and zinc ore and concentrates produced in Arkansas in 1915 and 1916.*

| | 1915 | 1916 |
|---|---|---|
| Total crude ore.....short tons.. | 110,000 | 249,000 |
| Total concentrates in crude ore: | | |
| Lead.....per cent.. | 0.07 | 0.13 |
| Zinc.....do.... | 7.76 | 7.35 |
| Metal content of crude ore: | | |
| Lead.....do.... | .06 | .11 |
| Zinc.....do.... | 3.25 | 3.04 |
| Average lead content of galena concentrates.....do.... | 79.8 | 80.2 |
| Average zinc content of sphalerite concentrates[a].....do.... | 59.6 | 57.1 |
| Average zinc content of zinc silicate and carbonate[a].....do.... | 40.6 | 39.9 |
| Average value per ton: | | |
| Galena concentrates | $62.80 | $82.88 |
| Sphalerite concentrates | $68.21 | $67.50 |
| Zinc silicate and carbonate | $51.49 | $56.61 |

[a] Includes some mixed carbonate and sphalerite.

## NORTHERN ARKANSAS.

Considerable prospecting and some mining were carried on in northern Arkansas for many years, but the present development has mainly been accomplished since 1899, when there was a great rush to that field. The mines are principally in Boone and Marion counties and in the adjoining portions of Searcy and Newton counties, though there are also numerous mines and prospects in Baxter, Izard, Sharp, Lawrence, and other counties to the east, and deposits have been worked in Washington and Sevier counties, on the extreme western border of the State.

The ores are galena, sphalerite, and smithsonite, and the concentrates produced are generally of high grade and free from or very low in iron or lime. The sphalerite has frequently assayed 2 or 3 per cent above the price basis of 60 per cent metallic zinc content.

The sphalerite and smithsonite are shown by analysis to contain appreciable quantities of cadmium, especially in a yellow variety of smithsonite, known locally as "turkey fat," which shows as high as 0.8 per cent of cadmium. The ore bodies occur in fissures or crevices, in fault breccias, and in solution breccias. The ore deposits are for the most part found in limestone of early Ordovician age, but some also are found in the Boone limestone of Mississippian (lower Carboniferous) age.

The number of concentrating plants which treated sphalerite did not increase in 1916 and most of the plants were operated intermittently. Some mixed sphalerite and zinc carbonate concentrates were sold and these shipments are included under sphalerite, so that the reduction of 2.5 per cent in the average zinc content of sphalerite does not signify that the average assay of sphalerite sold was appreciably less in 1916 than in 1915.

The estimated quantity of ore treated increased from 110,000 tons in 1915 to 249,000 tons in 1916 and the average recovery of concentrates from such ore decreased from 7.83 per cent to 7.48 per cent. This decrease was the natural result of the more extended use of milling plants treating zinc carbonate ores.

Although there were more large operators in 1916, a large part of the production was from mines worked on a small scale. This is best shown by the fact that the total yield of all classes of concentrates, amounting to 18,618 tons, was derived from more than 150 mines or prospects.

The value of the recoverable lead and zinc from ore shipped from Arkansas in 1916 was more than $1,000,000 greater than in 1915. The production of sphalerite concentrates increased from 606 tons in 1915 to 1,670 tons in 1916. This increase was not so large as was reasonably anticipated, for more than half the output was shipped from two old mines—the Silver Hollow, at Rush, and the Bonanza, on Cow Creek. The remainder of the sphalerite was derived from about 30 mines and prospects. Many districts were actively developed and numerous properties were equipped with mills. At other prospects the miners very wisely confined their efforts to mining and shipping hand cobbed concentrates pending the accumulation of sufficient milling ore to justify the erection of a mill.

Mining leases were granted on reasonable royalties and in consequence a considerable amount of money from outside the State was invested. There are, however, urgent reasons for landowners to undertake an active drilling campaign. Until such action is taken it is not reasonable to expect outside capitalists to invest largely in sphalerite prospects when large areas of drill-proved mineral land can be obtained in Oklahoma, Kansas, and Missouri.

Some improvement was made on the wagon roads in the mining districts, but the poor transportation facilities still hamper mining in many sections. An organized effort is now being made in Marion, Searcy, and Newton counties to establish an adequate system of good roads between the railway points and all outlying mining camps. The grading and most of the bridges on the proposed narrow-gage railway between Yellville and Rush were finished in the summer of 1916, but the construction work was not completed. The operation of the numerous mines on Rush Creek and Buffalo River remained entirely dependent on wagon transportation, and the

shipment of food, concentrates, and supplies for mill and house construction was expensive and uncertain. The railway will probably be completed when financial arrangements can be made but not in time to have any effect on the mine output in 1917. There was a distinct advance in mining and milling methods and a more extended use of tables to recover the fine ore. At Zinc large quantities of old dump material remaining at mines after the shipment of hand cobbed carbonate, was treated at custom mills. A mill is also under construction at Yellville at which it is proposed to treat mixed carbonate and sphalerite ores, of which there is a large quantity available. It is hoped that the mill will successfully separate the sphalerite and carbonate, for in many Arkansas mines there are large quantities of this mixed ore which is not desired by the smelters and is only reluctantly purchased and at very much lower prices than the straight sphalerite.

Notwithstanding the superior shipping facilities and fairly good roads in Boone County, the mine shipments did not increase so much as expected, and the shipments of concentrates from mines in Newton County exceeded those from Boone County, and those made from mines in Searcy County were nearly equal to those from Boone County. The Rush district in Marion County was in 1916, as in 1915, the largest producer of zinc concentrates, and Marion County produced more than half of all Arkansas zinc concentrates. Newton County will undoubtedly have a much larger production in 1917 than in 1916, for many old mines were reopened and new ones developed in the Cave Springs, Mount Hersey, Ponca, and Jasper districts. Particulars of the mill construction and development work done in 1916 are given in the review by districts and the assistance rendered by R. W. Willett and J. H. Hand, of Yellville, and by other mine operators in checking such data is gratefully acknowledged. It is regretted that many operators of mines in Arkansas, particularly the owners of small prospects, do not keep an accurate record of the quantity of dirt or ore mined and treated, the quantity of lead and zinc concentrates sold, the average assay of each class of concentrates, and the actual selling value of concentrates. If such data were kept by every mine operator and promptly transmitted, upon request, to the Geological Survey, the work of this Survey would be facilitated. Moreover, the mine owner himself would have exact figures instead of mere guesses to show prospective purchasers.

The shipments of lead concentrates from mines increased from 79 tons in 1915 to 339 tons in 1916. The production of sphalerite concentrates was 1,670 tons, or 1,064 tons more than in 1915, and the value increased, from $41,314 in 1915 to $112,726 in 1916. The sales of zinc carbonate concentrates increased from 7,925 tons, valued at $408,079, in 1915, to 16,609 tons, valued at $940,224, in 1916. The recoverable lead content of galena concentrates shipped amounted to 272 tons, valued at $37,536, and the recoverable zinc from zinc concentrates was 6,815 tons, valued at $1,826,420 in 1916. Mines in Marion, Boone, Newton, Searcy, Sharpe, and Lawrence counties produced all the zinc concentrates shipped in 1916, and mines in Newton County produced 324 tons of the total shipments (339 tons) of galena concentrates. Mines in Lawrence and Sharpe counties shipped 72 tons of sphalerite and 41 tons of zinc carbonate in 1916. The shipments from Boone County were 159 tons of sphalerite and

2,552 tons of zinc carbonate and silicate; those from Newton County were 324 tons of galena, 63 tons of sphalerite, and 2,640 tons of zinc carbonate. Mines in Searcy County shipped 26 tons of sphalerite and 2,102 tons of zinc carbonate. Shipments of concentrates from Marion County were much larger than those from all other Arkansas counties combined, and amounted to 10 tons of galena, 1,340 tons of sphalerite, and 9,292 tons of zinc carbonate.

## REVIEW BY DISTRICTS.

*Baxter County.*—Although considerable prospecting and development work was done in the Trimble Flat, Pigeon Creek, Jenkins Creek, and Bald Dave districts in Baxter County, none of the mines reported the sale of lead or zinc concentrates in 1916. Among the properties which were being developed were the Hulsenbeck, owned by Frank Strickland; the Boyd and Grand Glaze, owned by C. C. Feemster; the Michigan, owned by the J. C. Shepherd Mining Co.; the Jones, owned by Johnson & Browning; and the Shiras, owned by the S. C. A. Mining Co. None of the mines are equipped with concentrating plants.

*Lawrence and Sharp counties.*—The production in 1916 from these counties, which are in the most easterly part of the northern Arkansas region, although larger than in 1915, consisted of small shipments of sphalerite and zinc carbonate from about 10 mines or prospects, of which only one was in Sharp County. The largest producer of sphalerite was the Pearce mine of the Lavender Mining & Milling Co. in sec. 10, T. 15 N., R. 4 W., in Sharp County. The ore was hoisted from the 50-foot level and milled at an old 40-ton concentrating plant. The mine was closed in June, 1916, pending the construction of a new plant. The Hoppe and Calamine mines, belonging to the same company, were idle in 1916. The Kimberland land was worked by the Mattie L. Mining Co. and the Lucky Dog Mining Co. A new 75-ton mill was constructed at the Lucky Dog, and some ore taken from an open cut was milled. The Pine Ridge Mining Co. continued development of sulphide ore bodies on the Gibson land in the Black Rock district and also shipped a small quantity of sphalerite. Small shipments of sphalerite and zinc carbonate were made from the old Lincoln mine by the Cooperative Zinc Ores Co. Some development work was done prior to June, 1916, at the mines belonging to the Consolidated Zinc & Rock Co. situated in secs. 20 and 21, T. 17 N., R. 1 W. There is a 100-ton mill on the property. Small quantities of zinc carbonate concentrates were mined by Toler & Davidson and other prospectors near Smithville and shipped from Imboden.

*Washington County.*—The only production reported in 1916 from Washington County was a small quantity of galena and sphalerite shipped by the Morrow Mining Co., operating in sec. 25, T. 14 N., R. 33 W. The property is equipped with a 150-ton concentrating plant and the ore is taken from open workings.

*Boone County.*—Nearly all the concentrate produced in Boone County was shipped from Zinc. Most of the ore was the output of mines in the immediate vicinity of Zinc, especially from those on the Coon Hollow and Almy lands. The production of sphalerite concentrates in Boone County amounted to 140 tons and that of zinc carbonate to 2,552 tons. In addition to these shipments, several

hundred tons of zinc carbonate, which was derived from mines in Marion County near the border line of Boone County, were shipped from Zinc.

Most of the sphalerite was from the Coker Hollow mine, which was operated part of the year. A small quantity of sphalerite concentrates and a considerable output of zinc carbonate were shipped from the land of the Earl Mining & Smelting Co., which is equipped with a 150-ton concentrating plant.

On the Almy land the producing leases were the Brown, Taylor, & Conway, the Jackson, and the Gloria. Two mills were operated, one of 50 tons, by W. H. Almy, and the other of 150 tons, by the Jackson Mining Co. Both milled carbonate ore and hand-cobbed carbonate was shipped from the Almy land. The old mill at the Jackson lease was remodeled and improved, and sphalerite and carbonate concentrates were shipped. The ore treated was taken from a tunnel, although there is a shaft 106 feet deep at the mine. The Frisco mine and other leases were operated by L. L. Brown, who also treated waste from the dumps of his mines, and that from adjoining lands in Sugar Orchard district, at a 30-ton concentrating plant. The largest production of lump zinc carbonate was that from the Cantrell lease of the Lead Hill Mining & Smelting Co.'s land in Coon Hollow, which was worked by various sublessees. The Era Mining Co. started the erection of a 40-ton mill in Coon Hollow. L. T. Westrich shipped a considerable quantity of zinc carbonate, part of which was purchased from small operators and the remainder was mined from the Bailey, Miller, Manchester & Rhodes, and Iola lands. The mills at the Iola and the Broome County mines were idle all year, and the only production was that of lessees who mined zinc carbonate from shallow workings. Some hand-cobbed zinc carbonate was shipped from the J. N. Milum land, at Pyatt, by A. M. Walters, and hand jigs were used at the Edwin Juhre lease to clean ore taken from open cuts and short tunnels.

*Newton County.*—From mines in the Mount Hersey, Yardell, Marble City, and Cave Creek districts, in the eastern part, and the Ponca and Jasper districts in the western part of Newton County, there were shipped 324 tons of lead concentrates, 63 tons of sphalerite, and 2,640 tons of zinc carbonate. This output was six times as large as that of 1915 and was only exceeded by that of Marion County. This increased output was made notwithstanding the necessity of hauling supplies and ore shipments for long distances over poor roads. Transportation facilities are being improved, and the reopening of old mines and the development of new ones in all the districts will result in a much larger production in 1917.

The largest quantity of zinc carbonate concentrates was shipped from the Bennett land, which is 1½ miles southwest of Ponca. The first lessee on this property was the Eleventh Hour Mining Co., and the output was mainly that of sublessees, among which were Primrose & Sons, Chafin & Co., Key, Cook & Co., E. Garlinghouse, Big Four Mining Co., M. & H. Mining Co., G. N. Capps, and Knight & Bro. The ore was mined from the surface to a depth of 146 feet by means of open cuts and 12 shafts. Some of the concentrates were recovered by hand jigs, but most of the shipments were of hand-cobbed lump ore. The output was very large for a property handicapped by the necessity of transporting all concentrates 30 miles to Harrison, the

nearest railway station. About 95 per cent of the galena concentrates shipped from Arkansas came from mines in the Ponca and Jasper districts, in Newton County. Most of this galena came from the Isaac Kilgore lease on the Baker land near Ponca, which is opened by an 800-foot tunnel. The ore which is found in a soft shale underneath a sandstone capping is all cleaned by hand, and it is not unusual to recover chunks weighing several hundred pounds. Adjoining the Kilgore tunnel is a mine known as the Stover tunnel operated by Minicus & Villines. This tunnel produced quite a large quantity of zinc silicate and carbonate and some galena. The ore is found in filled-in caves. Directly west of Ponca, L. E. Lake has two tunnels driven into the hillside on the Brewer land, from which several carloads of zinc carbonate concentrates were extracted.

The Bonanza Mining Co. was another shipper of zinc carbonate in 1916. The ore mined was taken from an open cut and treated by means of hand jigs.

The production from the Jasper district in 1916 was about 250 tons of zinc carbonate, 14 tons of galena, and a small quantity of sphalerite. A new 50-ton concentrating plant was built by the Panther Creek Mining Co. in sec. 31, T. 16 N., R. 21 W., and a small quantity of ore taken from shallow workings was milled. Most of the sphalerite shipped from Newton County in 1916 was the product of this mine. Zinc carbonate concentrates and a small amount of galena were also recovered and shipped. The Low Gap mine, which produced galena and zinc carbonate concentrates, was sold by C. J. Chapman to W. A. McCurry. The lease on the old Spanish La Marr mine was transferred to H. E. Delaney, who shipped zinc carbonate taken from a 500-foot tunnel. Several mines, including the Big Tom and Jack Pot, were worked by E. R. Springer, and zinc carbonate concentrates were shipped. Most of the ore was taken from the Big Tom mine, on which there are three shafts, 42, 64, and 60 feet deep.

The Speers mine, in sec. 9, T. 16 N., R. 19 W., was the only producer in the Yardell district. The ore mined in 1916 was taken from an open cut 10 to 40 feet in depth and milled at a 100-ton concentrating plant. There is a 147-foot shaft at this mine, which is said to show a good face of sphalerite below the 40-foot level. A new 60-ton concentrating plant was erected in 1916 at the old Marble and Gibson mines in sec. 29, T. 17 N., R. 20 W., by the Marble City Zinc & Marble Co., and some sphalerite concentrates were shipped. The mine and mill are now leased to the Continental Mining Co.

Nearly all the ore shipped from the Cave Creek and Mount Hersey districts in the eastern part of Newton County was zinc carbonate mined by lessees of the American Zinc, Lead & Smelting Co. (formerly Granby land). The output from this land was much larger in 1916 than in 1915, and the development indicates an even larger production. The principal producing leases were the Bald Hill Mining Co., Williams & Truitt, and J. T. Venable & Co. (North Slope mine). The old Confederate mine was operated by the Moore Mining Co. in 1916, but has since been transferred to the Confederate Mining Co., which is building a 250-ton concentrating plant. All the ore shipped in 1916 from the Cave Creek district was lump concentrates or a hand-jigged product. The ore was mined by means of six shafts, none of which exceeded 60 feet in depth. The Lost Mountain Mining

Co. shipped a quantity of zinc carbonate obtained by means of five shafts from 20 to 45 feet in depth on secs. 1 and 2, T. 13 N., R. 19 W.

*Searcy County.*—The mines in Searcy County produced 26 tons of sphalerite and 2,102 tons of zinc carbonate in 1916, which was nearly ten times greater than the production in 1915. About 65 per cent of this output came from the Big Hurricane mine of the J. C. Shepherd Mining Co. in sec. 7, T. 16 N., R. 18 W. The ore milled in the 50-ton plant was taken from open cuts, and the tailings from this 50-ton plant and from the old dump were treated at a new 150-ton concentrating plant which is equipped with a Hardinge ball mill, a Dorr thickener, and 12 Wilfley sludge tables. The production from this property was the largest in Arkansas in 1916.

Another prominent producer of zinc carbonate was the Evening Star & Churchill Mining Co. in the Water Creek district, which mined ore by means of three shafts and treated it at a 150-ton concentrating plant. The N. W. Redwine Mining Co. developed a new mine in sec. 10, T. 16 N., R. 15 W., and built a 150-ton concentrating plant. Good recoveries of zinc carbonate were made from the ore milled. The 150-ton plant of the Maumee Joplin Mining Co., near Maumee, was operated part of the year. New ore bodies were located 1,500 feet from the mill, which will make the construction of a tramway necessary.

The Silver Run Mining Co. completed a 100-ton mill at the Massengale mine in sec. 6, T. 16 N., R. 15 W., but scarcity of water made it necessary to stop milling after a short run. The Massengale mine was the only producer of milled sphalerite in Searcy County in 1916.

Some lump carbonate ore was shipped from the Reeves mine in sec. 9, T. 16 N., R. 15 W. This mine, which is on Water Creek, was sold in 1916 to the Alverta Mining Co., which built a 100-ton concentrating plant equipped with oil engines, air compressor, and three tables. The plant was not ready for operation until January, 1917. Among other producing mines in Searcy County in 1916 were the Hazel Dell mine in sec. 16, T. 16 N., R. 16 W., owned by George Plank, of Gilbert, Ark., and the Tomahawk mine belonging to Calvin and David Lockhart, of St. Joe, Ark.

*Marion County.*—More than 60 mines and prospects in the Rush, Dodd City, Kingdon Springs, Buffalo, Yellville, Hall Mountain, Jimmy Creek, and other districts produced lead or zinc concentrates in 1916. The total output of mines in Marion County in 1916 was 10 tons of galena concentrates, valued at $780, 1,340 tons of sphalerite concentrates, valued at $91,109, and 9,292 tons of zinc carbonate concentrates, valued at $576,309. The quantity of sphalerite sold increased more than 900 tons and that of zinc carbonate 3,000 tons, and about 62 per cent of the total amount paid for all classes of zinc and lead concentrates from Arkansas mines in 1916 was received by owners of mines in Marion County.

There were many mines in the Dodd City district from which sphalerite or zinc carbonate was shipped in 1916, though none were large producers. Among the producing mines were the Bear Hill, Compound, Paradis & Durham, Edna Bee, McKay, North Pole, Governor Eagle, Markle, Pigeon, Onwatta No. 1, and Onwatta No. 2. The 150-ton plant of the Bear Hill Mining Co. was completed in 1916 and was operated for a short time. Two cars of sphalerite concentrates were shipped before operations were suspended on account

of an inadequate supply of water for milling. Both sphalerite and zinc carbonate were shipped from the Compound mine on the Gus Young land and also from the Paradis Mining Co. on the McDonald land. The ore on both these properties was taken from open cuts and shipped without treatment. Some hand-cobbed zinc carbonate was shipped from the Edna Bee mine prior to its sale to the Salina Mining Co. The 100-ton mill erected by the new owners was not completed until 1917.

The output from the Stillwell lease on the McKay land and from the Paradis & Wirth lease on the Hughson land was limited to zinc carbonate taken from shallow workings. The Governor Eagle mine and 100-ton mill were operated by the Pyatt Mining Co., which shipped about two cars of sphalerite concentrates. The Markle mine was operated part of the year by Markle & McCurry and then the lease was transferred to the Quapaw Mining Co. The mill at this mine was used to treat some custom ores in addition to ore from the Markle mine.

The larger part of the small galena output of Marion County was shipped by the Arkansas Mining & Mercantile Co. from the Pigeon mine, in sec. 32, T. 20 N., R. 17 W. The old Onwatta was worked by A. L. Morrow, and Onwatta No. 2, on the Clifford land, was operated by Settles & Reed. The hand-cobbed zinc carbonate from both these mines was high grade.

The Beatty mine in sec. 1, T. 19 N., R. 17 W., was operated by Wade Luckett and a small 50-ton mill was completed late in the year. A small quantity of sphalerite concentrates was shipped.

The larger producing properties in the Kingdon Springs and Jimmy Creek districts were the Blue Flag and Silver Cap mines operated by Seawell Bros. and the Big Buffalo mine leased to W. C. Aubrey. A 100-ton concentrating plant is now being built at the Big Buffalo mine. A small quantity of zinc carbonate was shipped from the Erie Ozark mine before it was closed because of litigation, and two carloads of carbonate were shipped by J. B. Rowden from the W. R. Kendall land. No ore was shipped from the Monkey Hill or Fullbright mines in 1916, but the old mill at the Monkey Hill was rebuilt by Zimmerman & Tillar. The Fullbright mine was purchased by the Marion Zinc Co. and a fully equipped 200-ton plant was completed. The mine workings include 14 open cuts, 2 tunnels, and an 80-foot shaft.

There were a number of producing mines in the Hall Mountain district and other districts tributary to Yellville. The largest production in 1916 of this group of mines and prospects was that of the Crooked Creek Mining Co., on the R. W. Willett land, in sec. 13, T. 18 N., R. 16 W. This mine is opened by tunnels 150 and 100 feet long, from which about three cars of zinc carbonate were shipped. Smaller shipments of carbonate were made from the Little Rock mine, operated by Paul L. Wood, and the Ohio mine, operated by M. Drennon. The Ohio mine also yielded a few tons of sphalerite. Hand jigs were operated at the R. H. Floyd lease of the Holden land to treat sphalerite ore taken from a 200-foot tunnel. The Climax mine between Yellville and Rush was reopened and about one car of sphalerite concentrates was shipped. No shipments of concentrates were made from the Blue John lease of E. B. Griswold or the Upde-

graff mine leased to J. M. Morrow, though some ore was recovered at both properties.

Some sphalerite and a large quantity of zinc carbonate was shipped from Everton. Nearly all of the carbonate came from the Marguerite mine of J. E. Potts and Thomas F. Hoye in sec. 33, T. 18 N., R. 18 W. This mine was one of the largest producers of hand-cobbed carbonate in Arkansas, and a 100-ton concentrating plant will be built to mill the tailings now on the dump. Both zinc carbonate concentrates and sphalerite concentrates were shipped by the Clear Creek Mining Co. from sec. 27, T. 18 N., R. 18 W., and a 150-ton concentrating plant was completed in December, 1916. This plant is equipped with oil-burning engines and three Wilfley tables. New concentrating plants are being built by the Everton Mining & Development Co. and the Myers Mining Co. Some hand-cobbed carbonate was shipped in 1916 from the B. J. Reed mine in sec. 34, T. 17 N., R. 17 W., and several other properties were being developed. The nearest railway station to the mines in this district is St. Joe, in Searcy County.

The zinc carbonate produced in the Water Creek district in 1916 was shipped from Gilbert in Searcy County. The two producing properties are in secs. 34 and 35, T. 17 N., R. 16 W. Sure Pop No. 1, belonging to the J. C. Shepherd Mining Co., was a large producer of high-grade zinc carbonate. The ore milled at the 45-ton plant was taken from the new tunnel 400 feet long on the north side of Water Creek and was conveyed to the mill by means of an elevated tramway 600 feet in length. Sure Pop No. 2 was developed by Markle & Kennedy and a 150-ton concentrating plant was finished in August, 1916. Some concentrates were shipped and developments indicate that the mine will have a large production in 1917. No shipments were made by the Stand Pat Mining Co., which is also in Water Creek district, but considerable development work was done. A number of prospects were developed in the Warner Creek district and small shipments of ore were made. Among the active properties were the Cave Spring, Myrtle, Little Jim, Emery, and Legal Tender mines.

The producing mines in the Buffalo district (including Cow Creek and Boat Creek) were the Boyd, Bonanza, Chickasaw, Lucky Dutchman, Fox Den, Ground Hog, Lion Hill, Monarch, Rich Hill, and Toney F. The Indiana Mining & Developing Co. operated the Ground Hog mine in 1916 and was the largest shipper of zinc carbonate. The sphalerite concentrates shipped were mainly those from the old Bonanza mine on Cow Creek, which has a 75-foot shaft and a 75-ton mill. The ore milled was taken from an open cut 40 feet deep and from two tunnels driven in 1916. A 40-ton concentrating plant was built at the Fox Den mine on the Paddock land in sec. 9, T. 17 N., R. 14 W., by J. E. Dow. Some ore was taken out while running a 75-foot tunnel and a small quantity of sphalerite was sold. Sphalerite ore taken from an open cut on the same land was milled by the Chickasaw Mining Co. The 150-ton mill at the Chickasaw, which was built in 1916, was also used to mill some ore from the Fox Den and Ground Hog mines. A large amount of prospecting was done at the Toney F. and Rich Hill mines in sec. 7, T. 17 N., R. 14 W., but only one car of zinc carbonate was shipped. Several properties on Buffalo River, including the Gunsight, the Bluff, and the

Gatling mines, were under development by E. B. Griswold, but no shipments of ore were made. A 100-ton mill was erected at the Dixie Girl mine on Boat Creek, which was not operated in 1916.

*Rush district.*—The Rush district had more mines in steady operation than any other district in Arkansas. Its mines yielded about 40 per cent of the total zinc concentrates from Arkansas in 1916. At times it was difficult to obtain delivery of provisions, mine supplies, and mill equipment on account of the bad condition of the wagon roads between Rush and Yellville and Rush and Buffalo. Notwithstanding such conditions the district was one of the most active in the Central States, and substantial additions were made to the equipment of the mines at Rush and in the territory tributary to Rush.

In 1916, as in former years, the Silver Hollow mine was the only shipper of sphalerite concentrates. The production of sphalerite from this mine, which has a 100-ton mill, was considerably larger in 1916 than in 1915. The sulphide ore body mined through the 850-foot tunnel was found to extend to levels lower than those worked in 1915. A considerable quantity of lump zinc carbonate was also extracted from openings on the bluff above the mill.

The 100-ton mill at the Yellow Rose mine, which had a large output of hand-cobbed zinc carbonate in 1915, was completed and used to mill ore taken from tunnels and from the large dump accumulated in 1915. Shipments of zinc carbonate concentrates were also made from the White Eagle mine on the Yellow Rose lease by the Maxine Mining Co., which erected a 100-ton concentrating plant. The mine was subsequently sold to the Arkahoma Mining Co.

The old Red Cloud mine was operated in January and February, 1916, by Zimmerman & Schofield and was then taken over by the Gertrude Mining Co. No. 2, of which J. C. Shepherd is the principal owner. The Red Cloud mine and a 17-acre lease from the Buffalo Copper & Zinc Co. was actively worked by the new owners. The Edith Mining Co., which is also located on a lease from the Buffalo Copper & Zinc. Co., completed its 150-ton concentrating plant and was one of the largest shippers of zinc carbonate in Arkansas in 1916. The mine, which is on the west bank of Buffalo River, is equipped with three shafts, of which only one—65 feet deep—was used in 1916.

The 100-ton mill at the Helva mine, owned by the Standard Zinc Co., was not completed in 1916 and no concentrates were shipped. Lump zinc carbonate concentrates were shipped from the O'Meara mine on the Clinton Zinc Co. land, sec. 18, T. 17 N., R. 14 W., and a 100-ton mill will be built in 1917. The Loney Boy, Mattie May, and other mines were under development by Edward Zimmerman, but the zinc carbonate ore taken out was not sold.

The Morning Star, Capps, and Carney mines were all operated by the Morning Star Mining Co., and the ore mined was milled at the 100-ton plant of the Morning Star mine. A long tramway connecting the Capps mine with the mill was completed. The production of this group of mines was considerably larger in 1916 than in 1915, and a large part of the output was derived from the Capps mine.

The mines at Rush operated by the J. C. Shepherd Mining Co. were the Philadelphia, Leader, McIntosh, and Monte Cristo. The mill at the Philadelphia mine, which was the largest producing property, was improved by the addition of two Fairbanks-Morse 100-horsepower oil engines, an Ingersoll air compressor, and an electric lighting plant.

The ore mined from both the Philadelphia and the Monte Cristo mines was treated at the Philadelphia mill. An aerial tramway 1,350 feet long, with a capacity of 10 tons per hour, connecting the Monte Cristo mine with the Philadelphia mill, was under construction. This tramway was not completed until February, 1917, so that the output of the Monte Cristo mine will be much larger in 1917 than in 1916. The 100-ton concentrating plant at the McIntosh mine is one of the most efficient in Arkansas and was used to treat the zinc carbonate ores from both the McIntosh and the Leader mines.

## ILLINOIS.

By J. P. DUNLOP.

### PRODUCTION.

In the chapter entitled "Silver, copper, lead, and zinc in the Central States" of Mineral Resources for 1914 was given a historical review and bibliography of the literature relating to the mining of lead and zinc in the northern and southern districts of the State of Illinois. Estimates were also given of the total quantity of concentrates and metal produced to the end of 1914.

*Mine production of lead and zinc in Illinois in 1916.*[a]

| District. | Ores. | | | | Metal content. | | | |
|---|---|---|---|---|---|---|---|---|
| | Lead concentrates (galena). | | Zinc concentrates. | | Lead. | | Zinc. | |
| | Quantity (short tons). | Value. | Sphalerite. | | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| | | | Quantity (short tons). | Value. | | | | |
| Northern Illinois..... | 676 | $46,853 | 15,211 | $461,045 | 462 | $63,756 | 3,404 | $912,272 |
| Southern Illinois..... | 874 | 66,751 | ..... | ..... | 610 | 84,180 | ..... | ..... |
| Total, 1915..... | 1,550 | 113,604 | 15,211 | 461,045 | 1,072 | 147,936 | 3,404 | 912,272 |
| Total, 1916..... | 1,320 | 59,944 | 20,454 | 751,277 | 954 | 89,676 | 5,534 | 1,372,432 |

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses in zinc but not in lead. In comparing the values of ore and metal it should be borne in mind thet the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily spot quotations at New York and the value of the zinc from the average sales price of all grades reported by the smelters.

*Mine production of silver in southern Illinois, 1907–1916.*

| | Silver. | | Lead concentrates, silver bearing. | | | Silver. | | Lead concentrates, silver bearing. | |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (short tons). | Ounces of silver per ton. | | Quantity (fine ounces). | Value. | Quantity (short tons). | Ounces of silver per ton. |
| 1907..... | 2,852 | $1,882 | 497 | 5.74 | 1912..... | 4,731 | $2,909 | 743 | 6.31 |
| 1908..... | 2,051 | 1,087 | 359 | 5.71 | 1913..... | 3,541 | 2,139 | 507 | 7.00 |
| 1909..... | 1,011 | 526 | 259 | 3.90 | 1914..... | 2,112 | 1,168 | 308 | 6.86 |
| 1910..... | 2,022 | 1,092 | 398 | 5.08 | 1915..... | 3,864 | 1,959 | 641 | 6.03 |
| 1911..... | 3,036 | 1,609 | 482 | 6.25 | 1916..... | 5,684 | 3,740 | 874 | 6.50 |

*Tenor of lead and zinc ore and concentrates produced in Illinois, 1915 and 1916.*

| | 1915 | 1916 |
|---|---|---|
| NORTHERN ILLINOIS. | | |
| Total crude ore.....short tons.. | 316,000 | 288,100 |
| Total concentrates in crude ore: | | |
| Lead.....per cent.. | 0.22 | 0.22 |
| Zinc.....do.... | 6.5 | 5.28 |
| Metal content of crude ore: | | |
| Lead.....do.... | .17 | .16 |
| Zinc.....do.... | 2.18 | 1.44 |
| Average lead content of galena concentrates.....do.... | 72.9 | 68.2 |
| Average zinc content of sphalerite concentrates.....do.... | 33.5 | 27.4 |
| Average value per ton: | | |
| Galena concentrates..... | $47.27 | $69.30 |
| Sphalerite concentrates..... | $36.73 | $30.31 |
| SOUTHERN ILLINOIS. | | |
| Average lead content of galena concentrates.....per cent.. | 71.6 | 70.0 |
| Average value per ton of galena concentrates..... | $43.45 | $76.38 |

The lead concentrates produced in southern Illinois are recovered in concentrating the fluorspar. To speak of the total crude ore raised as crude lead ore would be misleading. No attempt has been made, therefore, at calculating the quantity or the tenor of the crude ore.

The value of the mine production of silver, lead, and zinc in Illinois in 1916 was $1,063,948, as compared with $1,464,067 in 1915. The lead concentrates produced amounted to 1,550 short tons, which was 230 tons more than in 1915, and the recoverable lead content increased from 954 tons in 1915 to 1,072 tons in 1916.

The output of sphalerite concentrate decreased from 20,454 tons in 1915 to 15,211 tons in 1916, the recoverable zinc content of the concentrates decreased from 5,534 tons in 1915 to 3,404 tons in 1916, and the value decreased $460,160.

The silver recovered from lead concentrates amounted to 5,684 fine ounces, valued at $3,740, against 3,864 fine ounces, valued at $1,959 in 1915.

The lead and zinc deposits of Illinois fall into two distinct regions marked by different mineral association and structural environment. Those of southern Illinois belong to the Kentucky-Illinois fluorspar district; those of northern Illinois belong to the upper Mississippi Valley region.

## NORTHERN ILLINOIS.

The lead and zinc mines of northern Illinois are all in Jo Daviess County, the extreme northwest county of the State. The ores have the same structural relations as in the upper Mississippi district generally; that is, they occur disseminated through the limestone, or in openings in it called "crevices," "pitches," or "flats," depending on their attitude to the horizontal. These openings have, in general, an east and west trend, known as their "range." The ore bodies are sometimes continuous for long distances along these "ranges," which for that reason largely control the prospecting, both by shafts and by drilling. The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age.

The ores are galena, smithsonite, and sphalerite, though the two latter are much less common now than formerly, when the deposits

worked were mostly shallow and above water level. In early years the galena ores only were mined and the ore was taken from shallow pockets in quantities ranging from a few tons to several thousand.

Although the lead output of northern Illinois, Wisconsin, and Iowa has been large in the past and the ores have been smelted near the mines,[1] the output in recent years has been comparatively small and no ores have been smelted in those States.[2] The galena is practically nonargentiferous, and the zinc ores are not known to contain cadmium. Iron pyrites is very commonly associated with the ores, frequently in such quantity as to necessitate roasting and magnetic separation.

Two roasting and separating plants, one belonging to the Galena Refinery Co. and the other to the Wisconsin Zinc Co., were operated at Galena, and a large part of the raw concentrates was shipped to roasters in Wisconsin. Nearly all the zinc concentrates produced in the Galena district in 1916 were roasted before being shipped to smelters.

As none of the operators in the Sand Prairie district or in the Elizabeth district reported any production in 1916 the entire output of northern Illinois is included under the Galena district. The production of lead concentrates was 676 tons, valued at $46,853, as compared with 679 tons, valued at $32,093, in 1915.

There were 15,211 tons of sphalerite concentrates, valued at $461,045, produced in 1916, a decrease of 5,243 tons in quantity and of $290,232 in value.

The tonnage of crude ore mined decreased from 316,000 tons in 1915 to 288,100 tons in 1916. The average recovery of zinc concentrates from the ore milled decreased 1.22 per cent, and the percentage of lead was slightly more than in 1915.

The averge zinc content of the sphalerite concentrate decreased from 33.5 per cent in 1915 to 27.4 per cent in 1916.

*Galena district.*—The Galena district includes the mines in the vicinity of Fever River from Mississippi River to the Wisconsin State line. For many years the principal production was of lead ores, but in recent years the output of zinc has increased to such an extent that the lead is of minor importance. In 1907 the yield of zinc concentrates amounted to only 2,530 tons; in 1915 the output was 20,454 tons; and the output in 1916—15,211 tons—was more than that of any year other than 1915. There were a greater number of mines operated in 1916 and the decreased production was due to the much smaller yield from the Pittsburg and North Unity mines.

The largest production of lead and zinc concentrates in northern Illinois in 1916, as in 1914 and 1915, was derived from the old Marsdon-Black Jack mine of the Mineral Point Zinc Co. The mill was steadily operated during 1916 on dirt obtained by means of two shafts, one of which is 200 feet and the other 250 feet deep. The mill has a capacity of 600 tons in 24 hours and is driven by electric power. The mine is equipped with a steel head frame and a double-compartment mill shaft and the ore is hoisted in skips. The production from the Pittsburg mine, which is equipped with a 150-ton mill and a 30-ton roasting plant, was 5,000 tons less in 1916 than in 1915. An extensive cave-in of the workings and litigation resulted in the appointment of a

[1] Cox, G. H., Lead and zinc deposits of northwestern Illinois: Illinois Geol. Survey Bull. 21, p. 14, 1914.
[2] Pulsifer, H. B., History of lead smelting in Wisconsin: Min. and Eng. World, May 2, 1914, p. 821.

receiver for the Great Western Lead Mfg. Co. which owned the property, and the Pittsburgh mine was closed down early in the spring of 1916. Theodore Kollman and J. L. Nelson reported the shipment of some lead and zinc concentrates derived from tailings at the Vinegar Hill lease of the Stacey land. The output of the North Unity mine of the Vinegar Hill Zinc Co., on the Curran land, was the second largest in Illinois. The shaft at this mine is 175 feet deep and the mill has a capacity of 20 tons an hour. Drilling was done on the Copeland land and the Doyle land by the Vinegar Hill Zinc Co., and the leases may be mined in 1917. At the Graham land at Days Siding leased by this company, a shaft was sunk 193 feet deep and the erection of a 200-ton concentrating plant was completed.

A good production of galena concentrates was also mined on the Graham land by Bartell & Sherrill. The ore mined at the lower level by the Vinegar Hill Zinc Co. contained very little galena and that extracted from the 60-foot level by Bartell & Sherrill contained no appreciable quantity of sphalerite.

The 200-ton mill of the Wisconsin Zinc Co. at the Birkbeck mine near Days Siding was completed and operated early in 1916. The Southcott land, 1½ miles southeast of the Birkbeck mine, was being drilled by the Wisconsin Zinc Co. The Merry Widow mine was idle and no shipments of galena were made from the White Rose mine at which a new shaft was being sunk by Gus Brown. Small shipments of lead or zinc concentrates were made by Elia Georgeff, the Ophir Mining Co., C. A. Mitchell, and the Galena Zinc Co. The Joplin separating plant at Galena, which was leased to and operated by the Wisconsin Zinc Co., has a capacity of 70 tons of green concentrates a day. The equipment includes three Mathey type roasters and Cleveland-Knowles separators.

## SOUTHERN ILLINOIS.

The lead and zinc deposits of southern Illinois are found in Pope and Hardin counties in rocks of Mississippian age in the northern extension of the Kentucky-Illinois fluorspar district.

The principal product of the mines in recent years has been fluorspar, and the yield of galena is small compared with the output from other districts in the Central States. The total production of galena concentrates for southern Illinois, 1906 to 1916, inclusive, has been 5,319 tons, most of which has been shipped from the Fairview and Rosiclare mines. The shipments of zinc ores from the district have been comparatively small and scattered. The only recorded shipments of zinc carbonate were made from the Empire mine in 1903 or 1904, and in 1906 four companies made shipments aggregating 103 tons.

The structural relations and the mineralogic association are similar to those of the deposits of western Kentucky and in striking contrast to those of the deposits of northern Illinois. The ores occur in fissure veins, in association with jointing and faulting. The mines have been worked to depths of 300 and 500 feet without disclosing any decrease in the dimensions of the ore bodies. Dikes and sheets of lamprophyre and dikes of mica peridotite occur in the vicinity, but not in direct connection with the ore deposits. Galena is the most important metallic mineral. Formerly, and nearer the

surface, large bodies of galena were worked, but it is at present produced incidentally in the concentration of the fluorspar. For this reason it would be misleading to give the quantity of crude ore. As the district is not reached by railway, the product of the mines is dependent on river transportation.

The galena of southern Illinois is notably argentiferous as compared with the rest of the Mississippi Valley ores, the silver content ranging up to 12 and 14 fine ounces per ton of lead concentrates and averaging for the last seven years from 4 to 7 fine ounces per ton of lead concentrates. Sphalerite, or zinc blende, is the next important metallic mineral, but it occurs much less plentifully than galena. It is recovered as zinc middlings in the concentration of the fluorspar. The difficulty of making a clean separation of the zinc middlings has kept down the production of zinc. None has been sold from southern Illinois in the last eight years. The principal vein minerals are fluorspar, calcite, and barite.

The shipments of galena concentrates increased 233 tons in quantity, and the silver content recovered in treating the concentrates increased from 3,864 ounces in 1915 to 5,684 ounces in 1916. The average lead content of the concentrates decreased from 71.6 per cent in 1915 to 70 per cent in 1916. The average silver content per ton recovered from lead concentrates increased from 6.03 ounces in 1915 to 6.50 ounces in 1916.

The Fairview Fluorspar & Lead Co. operates on the Good Hope vein, which was first developed in 1862. Nearly all the ore mined in 1916 was hoisted through the Blue Diggings shaft and from the new shaft, 200 feet in depth, sunk in 1915 on what the operators consider the southern extension of the Good Hope vein. This company also took over and operated the Franklin mine, which is about 5½ miles from Marion, Ky.

The Rosiclare Lead & Fluorspar Co. operates on an ore body which is probably continuous with that of the Fairview. The main shaft at the Rosiclare has reached a depth of more than 500 feet, and the mine has a long record of continuous production. The steel and concrete mill, entirely fireproof, is designed to handle 500 tons a day and is provided with special facilities for saving the lead and zinc both by jigs and by tables. The lead recovered is stated to be about 0.8 per cent of the quantity of ore treated and the quantity of blende is practically negligible. The quantity of galena concentrates sold in 1916 was less than in 1915.

## IOWA.

By J. P. Dunlop.

The lead and zinc deposits of Iowa extend along Mississippi River for nearly 80 miles, in Dubuque, Clayton, and Alamakee counties. They are found in the Galena dolomite, of Ordovician age.

In early days the Dubuque mines were the most important source of lead in the United States, and in later years the mines, especially those in the vicinity of Durango, yielded considerable quantities of zinc-carbonate ore. Nearly all this earlier mining was done above water level, and only within the last few years has there been much attempt to mine below water level. Therefore the production, par-

ticularly of zinc-blende ore, for these years, though small, is noteworthy, since it represents the attempt to mine at deeper levels.

The ore deposits of the Dubuque district occur in crevices and in caves or "openings" along these crevices. Of these openings there are five or six, the "top," "middle," and "third" being the most prolific of ore. The "flats" and "pitches," common in the Wisconsin mines, have been found in only one or two places in Iowa. The crevices have an east-west trend and sometimes extend considerable distances, being mined at different places, in which case they are known as "ranges." The mining operations of recent years have generally been confined to attempts to find paying ore at deeper levels in these old ranges, which are known to have yielded ore in former days in the upper openings.

There was no production of either lead or zinc reported by Iowa mines in 1914 or in 1915. Most of the mining companies have ceased work and forfeited their charters. None of the mines in the Dubuque district were operated in 1916. The estimated output of 85 tons of sphalerite and 20 tons of galena concentrates in 1916 was derived from the treatment of old dumps and tailings. The estimated recoverable metal content of the concentrates shipped was 14 tons of lead, valued at $1,932, and 21 tons of zinc, valued at $5,628. It is not probable that there will be any increased production from old tailings in 1917.

## KANSAS.

By J. P. Dunlop.

### PRODUCTION.

*Production of lead and zinc in Kansas, 1916.*[a]

| District. | Ores. | | | | | | Metal content. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lead concentrates. | | Zinc concentrates. | | | | Lead. | | Zinc. | |
| | Galena. | | Sphalerite. | | Carbonate and silicate. | | | | | |
| | Quantity. (short tons). | Value. | Quantity. (short tons). | Value. | Quantity. (short tons). | Value. | Quantity. (short tons). | Value. | Quantity. (short tons). | Value. |
| Galena | 2,136 | $155,389 | 19,448 | $1,447,323 | 5 | $196 | 1,584 | $218,592 | 9,842 | $2,637,656 |
| Lawton | 70 | 5,727 | 3,786 | 290,112 | ..... | ..... | 55 | 7,590 | 2,041 | 546,988 |
| Badger-Peacock | 11 | 987 | 1,043 | 86,634 | ..... | ..... | 9 | 1,242 | 565 | 151,420 |
| State total, 1916 | 2,217 | 162,103 | 24,277 | 1,824,069 | 5 | 196 | 1,648 | 227,424 | 12,448 | 3,336,064 |
| 1915 | 1,618 | 85,415 | 27,753 | 1,923,971 | 71 | 2,522 | 1,212 | 113,928 | 14,365 | 3,562,520 |

[a] In calculating the metal content of the ores from assays, allowance has been made for smelting losses in zinc but not in lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily outside spot quotations at New York and the value of the zinc from the average sales price of all grades reported by the smelters.

*Tenor of lead and zinc ore and concentrates produced in Kansas, 1915 and 1916.*

| | 1915 | 1916 |
|---|---|---|
| Total crude ore.....short tons.. | 709,400 | 774,400 |
| Total concentrates in crude ore: | | |
| Lead.....per cent.. | 0.23 | 0.29 |
| Zinc.....do.... | 3.92 | 3.15 |
| Metal content of crude ore: | | |
| Lead.....do.... | .17 | .20 |
| Zinc.....do.... | 2.25 | 1.78 |
| Average lead content of galena concentrates.....do.... | 74.9 | 74.3 |
| Average zinc content of sphalerite concentrates.....do.... | 57.4 | 57.0 |
| Average zinc content of zinc silicate and carbonate.....do.... | 38.0 | 38.0 |
| Average value per ton: | | |
| Galena concentrates | $52.79 | $73.12 |
| Sphalerite concentrates | $68.96 | $75.13 |
| Zinc silicate and carbonate | $35.52 | $39.20 |

The lead and zinc deposits of Kansas, so far as developed, are limited to the southeastern portion of the State, in Cherokee County. They comprise the western extension of the ore deposits of the Joplin region and display the general characteristics of that area, except that here typical sheet-ground deposits have not been extensively developed. The ores are galena and lead carbonate, sphalerite or zinc blende, and zinc carbonate and silicate. The galena is practically nonargentiferous, carrying but a small fraction of an ounce of silver to the ton of lead concentrates.

It is difficult to obtain the production for early years or to segregate the Kansas ores from those produced in the adjoining portion of the Joplin region in Missouri. If to the figures obtained and published by the State Geological Survey of Kansas for the years 1886–1903 [1] are added those for the years 1904–1916, published by the United States Geological Survey, a total output of 1,045,460 tons of zinc concentrates and of 149,439 tons of lead concentrates is shown as the approximate production of Kansas for the years 1886–1916, inclusive.

The value of the mine production of lead and zinc in Kansas in 1916 was $3,563,488, against $3,676,448 in 1915.

The value of the recoverable lead in galena concentrates shipped from Kansas mines in 1916 was $227,424, just double that of 1915. The production of lead concentrates increased from 1,618 tons in 1915 to 2,217 tons in 1916, and the metal content from 1,212 tons to 1,648 tons. The percentage of lead concentrates in crude ore milled increased from 0.23 per cent in 1915 to 0.29 per cent in 1916. This increase was partly due to the greater quantity of ore from the "blanket ground" mined in 1916, and to a slightly increased output from small diggings worked under the stimulus of the much higher average price of galena in 1916.

The average lead content of the galena concentrates sold was 0.6 per cent less in 1916 than in 1915, but the average price received for such concentrates was $73.12 a ton, against $52.79 in 1915.

The production of zinc carbonate and silicate was only 5 tons, valued at $196, or 65 tons less than in 1915.

[1] Haworth, Erasmus, and others, History, geography, geology, and metallurgy of Galena-Joplin lead and zinc: Kansas University Geol. Survey, vol. 8, 1904.

The production of sphalerite concentrates in 1916 was 24,277 tons, valued at $1,824,069, a decrease of 3,476 tons in quantity and of $99,902 in value, as compared with 1915. Notwithstanding that there was only a small increase in the quantity of "sheet ground" ore mined, the proportion of sphalerite concentrates recovered from crude ore milled declined from 3.92 per cent in 1915 to 3.15 per cent in 1916. This decline was due to the natural tendency to mine lower-grade ores made profitable by the increase in the average selling price of sphalerite concentrates from $68.96 in 1915 to $75.13 in 1916. The average zinc content of the sphalerite concentrates shipped was slightly less in 1916 than in 1915. The decreased output of sphalerite in 1916 was due to the fact that most of the Galena mines were closed for several weeks on account of flooding. The reopening of the old mines at Badger-Peacock increased the Kansas production considerably. Thousands of acres of land were prospected by drilling in the northern extension of the Miami field in Kansas and also north of Lawton along the State line between Kansas and Missouri. The phenomenal activity extended for miles north and northwest from the producing mines in Oklahoma to lands lying in Cherokee County, Kans. Leases were taken on nearly every farm as far north as Columbus, and a steadily increasing number of drill rigs were engaged in prospecting or in blocking out ore. One new mine northeast of Lawton sold a small quantity of concentrates in 1916 but no sales were made by any of the new mines in the north extension of the Miami district until early in 1917. As there will be a number of concentrating plants in operation in this district and probably several new mills will be in operation northeast of Lawton the production of both lead and zinc in 1917 will probably exceed that of 1916.

### REVIEW BY DISTRICTS.

*Badger-Peacock district.*—The production of the Badger-Peacock district in 1916 was 11 tons of galena concentrates and 1,043 tons of sphalerite concentrates. The productive mines were all in secs. 23, 24, and 25, T. 33 S., R. 25 E., and the output was mainly that of the Joplin Royalty & Mining Co. and the lessees of the United Zinc Cos. A few tons of sphalerite were shipped by J. B. Meredith from the old Badger mine of the Middlesex Land & Mining Co., but the underground workings of the mines on that land were not unwatered. The Joplin Royalty & Mining Co. was the largest producer in the district. The ore was mined from drifts on the Missouri side of the State line between Kansas and Missouri, hoisted through a shaft located in Kansas, and treated at a 300-ton electrically equipped concentrating plant. The ore mined in 1916 was from "soft ground" at the 72-foot level, but another ore body, said to be in "sheet ground," which is to be mined in 1917 was developed at a depth of 96 feet. The old Peacock mines of the United Zinc Cos., which have been flooded since 1912, were finally unwatered and a dike constructed partly of rock and partly of concrete was built to protect the mine from the flood waters of Spring River. The old tailings were milled by the Joplin Zinc Ore Milling Co., and the Lehigh mill at Carl Junction was purchased by the Joplin-Peacock Zinc Corporation and rebuilt at Pea-

cock. This mill of 300 tons capacity was not ready for operation until late in 1916, when it was used to treat ore which was found already broken in the old drifts. The underground workings were found to be in good condition and the four shafts will be used by the lessees to hoist ore from the 148-foot level.

*Lawton district.*—The Lawton district, which is situated 3½ miles north of Badger-Peacock, produced less sphalerite in 1916 than it did in 1915. The decline was not due to lessened activity in the district, for drilling was done on a large area of land adjoining and north of the original producing properties and the village of Lawton increased rapidly in population. The output of the Eastern mine was less than in previous years because in the latter part of 1916 the owners were engaged in lowering the working level of the mine, and in consequence a large quantity of lower grade dirt was milled which reduced the average recovery in concentrates. This development work was finished early in 1917 and the average recovery of concentrates from milled dirt or ore will be about the usual 5 per cent. The plant is complete, the mine is efficiently worked, and development work is systematically done. The ore reserves indicate a steady production for many years. The 200-ton mill is located on the Robinson lease, and electric power is used to drive the mill and for pumping. Four shafts were used at various times to hoist ore, which was mainly derived from the 150-foot level. The H. L. & S. mine on land lying north of the Robinson land and owned in fee by the Eastern Lead & Zinc Co. was operated by the C. C. Yoder Mining Co. The 150-ton mill and mine were in operation for a part of the year and the production was less than usual. The Crane tailing mill of 200 tons capacity ran steadily on tailings from the Eastern mine and produced a large output of high-grade concentrates.

The Hall lease on the S. D. Ball land was worked for a short time by the Bonehead Mining Co., and the mill of the Greenfield & Lockwood Mining Co. on the same land was sold and removed. Considerable drilling was done in both Kansas and Missouri in the territory between Lawton, Kans., and Waco, Mo. The only producing property was that of the Acme Mining & Milling Co. on the Hurlbut land about 1½ miles northeast of Lawton. Seven holes were drilled on this lease, which indicated ore bodies between the 103 to 130 and 149 to 193 foot levels. An old shaft on the property had been abandoned for 10 years on account of the large quantity of water encountered; a new shaft was sunk to a depth of 125 feet, and a considerable quantity of ore was treated by means of hand jigs. A 200-ton mill was constructed at the old shaft, and a tramway was erected between the mill shaft and the new workings. Prospecting was also done by the Liberal Mining Co., St. Louis Joplin Mining Co., Waco Mining Co., High Five Mining Co., and others, on the Bennett, Dobbs, Irvin, and Houston lands. Many of the drill holes are said to have shown cuttings indicating extensive bodies of high-grade ore. Some of these ore bodies have been opened by shafts, and several mills are under construction, which will contribute largely to the production of lead and zinc in 1917.

*Galena district.*—The production of lead concentrates in the Galena district in 1916 was 2,136 tons, valued at $155,389, as compared with 1,581 tons, valued at $83,083, in 1915. The shipments of zinc concentrates (all of which was sphalerite except 5 tons) were 19,453

tons, a decrease of 2,746 tons; but, owing to the higher prices paid for zinc concentrates in 1916, the total value of the zinc concentrates was only $54,529 less than it was in 1915. There was a decrease of 66 tons in the quantity of zinc carbonate and silicate, and there were no sales of lead carbonate in 1916. The metal content of the lead concentrates was 1,584 tons in 1916, against 1,183 tons in 1915.

More low-grade ore and tailings were treated in 1916 than in 1915; but, although the quantity of dirt milled was slightly greater than in 1915, the average recovery of lead and zinc concentrates decreased materially. The average zinc content of sphalerite sold in the Galena district, as figured from the reports of the operators, was 56.2 per cent, which is a very close agreement with the average zinc assay of more than 2,100 sample lots made by A. J. Lusk, of Galena. The assays made by Lusk were used by buyers and sellers in settlements for ore and represent the average assay of sphalerite shipped from Galena. The average assay of 2,172 lots regardless of the weight of each lot sold was 56.09 per cent zinc and 1.98 per cent iron.

Many of the small leases at Galena are not equipped with concentrating plants, and a considerable part of the production is milled at custom mills or sold to chatters. Early in the year these custom plants were unable to handle all the ore delivered, but the heavy rains in June cut off a large part of the output of the small mines for several months. The flume in Short Creek was destroyed, all the mines adjacent thereto were flooded, and it was August or September before many of them were pumped out and cleaned of the débris.

Development work continued as usual, and several new mills were erected and some drilling was done, which showed ore bodies at lower levels than those at present being mined. As the production of the Joplin Royalty & Mining Co., Buckeye Mining Co., Joplin-Columbus Mining Co., and Shawnee Mining Co. were included with that of Galena in 1915 and not in 1916, the actual output of sphalerite from the Galena district proper was only about 1,200 tons less in 1916 than in 1915. Lessees on the Wyandotte Lead & Zinc Co. land reported the largest production of sphalerite and the second largest output of galena. The Diplomat mine was, as in other years, the largest shipper of galena concentrates. Among the more prominent of the new producing properties were the Wayland on the Wyandotte land, the Double Lew on the Page & Cobb land, and the Andrew on the Martin land.

The production by lessees on the South Side tract of the Playter Mining Co. was not so large as in 1915, for the land was flooded in June, 1916, and all levels below 100 feet were idle until November. Poole & Bailey, the largest operators on the tract, sunk a shaft to the 175-foot level and were hoisting dirt containing 6 per cent in concentrates. Typical "sheet ground" was opened up by Shead & Poole at the 100-foot level, and the Brushwood Mining Co. were engaged in sinking a 257-foot shaft to an ore body discovered by drilling. The Chase mill of 60 tons' capacity was operated by L. Soulen, and the 250-ton Goodeye mill by Poole & Playter. Twenty-two shafts were operated by various lessees before the flood in June temporarily suspended work.

The Diplomat mine was the only large producer on the land of the Galena Lead & Zinc Co., though a small quantity of galena was recovered by the Golconda Mining Co. while doing development work. The output of the Diplomat mine and that of the adjoining Empire mine, owned by Sapp & Long, was from blanket ground mined at the 100-foot level. The recovery of concentrates from this blanket ground was about 2 per cent. The Empire produced more sphalerite than the Diplomat, but the quantity of galena recovered was considerably less. An ore body lying between 211 and 275 feet deep was discovered by drilling at the Empire and a 15 by 6 foot shaft was being sunk. This shaft had reached a depth of 140 feet at the end of 1916.

The production of lessees on the Wyandotte Lead & Zinc Co.'s land in 1916 increased more than 100 per cent. The Wayland Mining Co. on this lease was one of the largest producers in the Galena district. The concentrating plant has a capacity of 300 tons (10 hours) and dirt was hoisted from the 80-foot level through four shafts, including one completed in 1916. The leasehold was thoroughly drilled and a lower run of ore which lies between 234 and 300 feet deep was discovered. The Manhart mill of 100 tons capacity was run on ore from the Gray Cat and Yellow Pup mines. The shaft at the Gray Cat is 93 feet deep and the ore body is rich and easily mined.

On the Page & Cobb land, adjoining the Wyandotte, drilling indicated that the lower run of ore discovered on the Wyandotte land extended to the Page & Cobb land. This lower run of ore was not mined in 1916 and the output of the Double Lew Mining Co. was derived from ore hoisted from the 70-foot level. This ore, which was probably the richest mined in the Galena district in 1916, was milled at the Promoter mill on the New Century land. A number of lessees on the New Century land had a good output of ore, part of which was milled at the Promoter mill.

Lessees of the Illinois Lead & Zinc Co., including the Boston Land & Mining Co., Peacock-Galena Mining Co., Little Homestake Mining Co., George Playter, Lone Elm Mining Co., and their sublessees, sold considerable sphalerite concentrates and would have had a large output if their property had not been flooded with water on several occasions. The Peacock-Galena mill, which has been sold to Compton & Porter, was run on custom ore. A large number of shafts were utilized by the numerous sublessees and all the ore mined was from levels above 100 feet. Two new shafts were sunk by Frank B. Wilcox, and the erection of a new concentrating plant was commenced.

The Latawanna land and mill of George L. McCullough were actively operated, though the production was reduced by the flooding of the property. Six shafts were used to hoist ore from an average depth of 90 feet. The old New York Zinc Co., about a mile southeast of Galena, was drilled by McCullough, and it is stated that a run of ore was struck at a depth of 250 feet which continued down to a depth of 290 feet.

The various interests controlled by James Murphy and W. L. Crockett, including the Empire Mining Co., Lockport Mining Co., Murphy Mining & Realty Co., and Windsor Lead & Zinc Co., made an output of lead and zinc concentrates which in the aggregate was a substantial part of the district production. Considerable loss was occasioned by the washing out of the flume on Short Creek in June.

The flume was rebuilt and the property brought back to a producing basis in September. Other delays which reduced the output materially were the frequent shutdowns caused by lack of electric power for pumps and milling plants.

The Andayer Mining Co.'s production from a new lease on the Boston Land & Mining Co. was small, but a large amount of development and construction work was done which is expected to result in a larger output in 1917. Ore was hoisted from one shaft and a new shaft was sunk to a body of ore located by drilling.

The Martin land at Empire was prospected by the Andrew Bros. Mining Co., and a new mill of 150 tons capacity was erected and put in operation in October. This mill was one of the largest producers of sphalerite in the district at the end of 1916, yielding an average recovery of about 13 per cent in concentrates from ore mined through a 96-foot shaft.

The West Virginia Mining Co. put the 200-ton mill on the Luscombe & McElroy land in operation in August and milled ore hoisted through 2 shafts about 110 feet deep.

The Hurry Up Mining Co. land was worked by the owners and also by some sublessees. The ore mined by the company was treated at a 150-ton concentrating plant at which new gas engines and other equipment were installed in 1916. The ore mined by lessees was treated at custom mills. Five drill holes were sunk on this property to depths lower than 300 feet. All of these drill holes are said to have encountered three deposits of sphalerite and galena as follows: From 50 to 135 feet, assaying an average of 5 per cent zinc and lead; from 185 to 210 feet, assaying an average of 6 per cent zinc and lead; from 269 to 310 feet, assaying an average of 9 per cent zinc and lead.

The Bonanza land was leased by the Nimmie Tam Mining Co., McKinney Mining Co., Lowdena Mining Co., and Forrester & Co. Numerous shafts, none of which exceeded 110 feet in depth, were operated, and the dirt was sent to custom mills. A 150-ton concentrating plant was under construction at the Lowdena lease of 40 acres. A new 175-ton plant was operated at the Ferguson land, which is located on the Kansas-Missouri State line, by the McClintock Mining Co. A considerable quantity of sphalerite concentrates was shipped, but apparently the mine was not worked at a profit, for the mill was removed and work was suspended.

The following lands and leases were mined and the operators sold substantial quantities of lead or zinc concentrates: W. P. Clement, on the Connor land; Clermont Land & Mining Co., Land & Cooley, Merchants Mining Co., lessees on the Templar Mining Co.'s land; E. B. Schermerhorn land; Fred Stone, on the Black Hills land. Other shipments were made by lessees of the J. K. Williams estate, Kennedy estate, Hoosier Mining Co., and L. K. Moeller.

The mill belonging to J. W. Squires was run steadily all the year, and the Millbrook tailing mill with an estimated capacity of 300 tons treated the old tailings from the Squires mill. The mill is equipped with gas engines, regrinding rolls, tables, Dorr classifier, and Dorr thickener. Concrete construction was used in part, and the mill is one of the most substantial and expensive tailing plants in the Joplin region. The new custom mill of Monlux & Co. was operated steadily and had a large output of both sphalerite and galena.

*Baxter-Blue Mound district.*—The activity in that part of Kansas that lies along the Oklahoma-Kansas State line from Baxter Springs for 8 miles westward and about 3 miles from north to south is simply the overlapping into Kansas of the progressive northerly development of mining territory from the vicinity of Commerce. None of the mines in this extension of the Miami field into Kansas had any output in 1916.

In this area there were at least 100 drill rigs at work at the close of 1916 and the number was being increased as rapidly as possible. From 18 to 25 drill rigs were operated by the Miami Zinc Syndicate under the direction of Victor Rakowsky, who explored and developed the rich deposits in the adjoining Picher district of Oklahoma. The Miami Zinc Syndicate, which controls under lease 4,000 acres in the Kansas field, is reported to be financed by the Hayden-Stone-Jackling interests, which are also interested in the Butte & Superior Mining Co. and in the American Zinc, Lead & Smelting Co. The American Metal Co. has taken over a large number of leases, including that on the Ebenstein land. The Commerce Mining & Royalty Co., which discovered and developed the original mines in the Miami district, controls 1,100 acres in Kansas; the Century Zinc Co., also a successful operator in the Picher field, controls 500 acres, which is being prospected with six drills; and Grantham & Pratt have 1,200 acres under lease. Church & Mabon, who are large operators in the original Miami district, and who developed the deposits in the vicinity of Century, have recently entered the Kansas field, operating as the Tri-State Mining Co., and are prospecting a large acreage. Many smaller companies and individuals are also prospecting in the region and the leasing of practically all the territory north and east of Baxter Springs presages further extension of the prospecting campaign in that direction.

Two shafts have been sunk to the upper run of ore on the Broom Factory tract, just north of the State line and the first of the Kansas tracts to be prospected. This tract is leased to the Commerce Mining & Royalty Co. The heavy volume of water has delayed the completion of the shafts, but the pumping done has enabled several mines lying south of the Commerce lease in Oklahoma to mine ore found in upper runs.

The Blue Mound Mining Co. sunk two shafts on the Toskopf land directly north of the Eagle Picher lease in Oklahoma and were erecting a 300-ton mill which was completed early in 1917. This mine is the first producer in Kansas located in the northerly extension of the Miami district. Shafts were also being sunk on the D. S. Chubb, A. H. Barr, L. Hocker, R. F. Hartley, Wilbur, and Ebenstein lands.

The ore, as developed by the shafts and the drilling, is similar in richness, depth, and type to that in the northerly development of the Miami field. In depth it ranges from 165 to 315 feet.

The Oklahoma, Kansas & Missouri Interurban Railway, which now extends to the Kansas line, is to be extended northward into Kansas and eastward to Baxter Springs. The Southwest Missouri Electric Railway Co. has announced a proposed extension from Galena, Kans., through Baxter Springs to Picher. These electric lines and the new Mineral Belt line now completed from Quapaw to Picher and to be extended to Baxter Springs will aid greatly in the development of the region by giving easy connection with Miami and Joplin.

# KENTUCKY.

By J. P. Dunlop.

## PRODUCTION.

Lead and zinc deposits are found in both central and western Kentucky. None of the mines in Franklin, Mercer, Scott, Owen, or Henry counties, in the central districts, reported any lead or zinc concentrates shipped in 1916. The mines in the flourspar region of western Kentucky are chiefly in Crittenden, Caldwell, and Livingston counties and form a continuation of the southern Illinois lead and zinc region. The earliest available records of the occurrence of flourspar and the associated galena in the Kentucky-Illinois region appeared in the first, second, and third volumes of the American Journal of Science, published in 1818, 1820, and 1821.[1]

The presence of zinc blende was recognized in 1854–1857 during the first geological survey of the State of Kentucky by David Duke Owen and his assistant, Sidney S. Lyon. The first lead smelter using galena from Kentucky was erected by the River Valley Mining Co. at the Royal mine[2] about 1870.

Considerable quantities of galena ores have been produced in former years, but at the present time lead is obtained solely as a by-product in the recovery and concentration of flourspar, which is the principal economic mineral. The galena recovered is argentiferous, the silver content varying from a very small quantity to over 3 ounces a ton, but no recovery of this silver content has been reported by the smelters during the last five years. The lead concentrate shipped in any one year from Kentucky does not necessarily represent the actual recovery of lead from flourspar mined in that year, for, being merely accessory to the flourspar and produced in small quantities, it is frequently held until a considerable quantity has accumulated or until lead prices are high.

*Mine production of lead and zinc in Kentucky, 1907–1916.*

| Year. | Ores. | | | | | | Metal content. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lead concentrates (galena). | | Zinc concentrates. | | | | Lead. | | Zinc. | |
| | | | Sphalerite. | | Zinc carbonate. | | | | | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| 1916 | 227 | $16,868 | 125 | $6,407 | 2,923 | $126,875 | 153 | $21,114 | 1,096 | $293,728 |
| 1915 | 370 | 17,103 | ..... | ..... | 2 172 | 106,079 | 251 | 23,594 | 764 | 189,472 |
| 1914 | 26 | 800 | 27 | 1,120 | 644 | 12,168 | 16 | 1,248 | 230 | 23,460 |
| 1913 | 40 | 1,422 | 198 | 5,206 | 696 | 13,811 | 22 | 1,936 | 327 | 36,624 |
| 1912 | 151 | 6,827 | 498 | 25,391 | 750 | 16,006 | 106 | 9,540 | 491 | 67,758 |
| 1911 | ..... | ..... | ..... | ..... | 467 | 10,604 | ..... | ..... | 158 | 18,012 |
| 1910 | 56 | 1,980 | ..... | ..... | 30 | 300 | 41 | 3,608 | 6 | 648 |
| 1909 | 12 | 620 | ..... | ..... | 150 | 1,701 | 10 | 860 | 64 | 6,912 |
| 1908 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1907 | 54 | 2,350 | ..... | ..... | ..... | ..... | 34 | 3,604 | ..... | ..... |

[1] Ulrich, E. O., and Smith, W. S. T., The lead, zinc, and fluorspar deposits of western Kentucky: U. S. Geol. Survey Prof. Paper 36, pp. 16–17, 1905.
[2] Fohs, F. J., Fluorspar deposits of Kentucky: Kentucky Geol. Survey Bull. 9, 1907.

The shipments of sphalerite concentrates from Kentucky in 1916 amounted to 125 tons. The shipments of zinc carbonate increased from 2,172 tons, valued at $106,079, in 1915 to 2,923 tons, valued at $126,875, in 1916. The estimated recoverable zinc content in 1916 was 1,096 tons, valued at $293,728.

The shipments of galena concentrates reported in 1916 were 227 tons, valued at $16,868, compared with 370 tons, valued at $17,103, in 1915. The average lead content was 68 per cent, compared with 67.8 per cent in 1915. The recoverable metallic content of the galena in 1916 was 153 tons, valued at $21,114.

The total value of the lead and zinc concentrates shipped from Kentucky mines was $150,150, as against $123,182 in 1915.

The principal sellers of galena concentrates were the Roberts Fluorspar & Lead Co., the Kentucky Fluorspar Co., and the Eclipse Mining Co. Part of the galena sold by the Roberts Fluorspar Co. was purchased and the remainder was obtained from fluorspar ore mined by means of three shafts having an average depth of about 120 feet and one shaft 170 feet deep. The Sanders ore separating plant which had been leased in 1915 was purchased in 1916. In addition to shipments of fluorspar and galena a small quantity of zinc carbonate was shipped.

No underground work was done at the Commodore mine by the Eclipse Mining Co. and none of the sphalerite concentrates recovered from old tailings were shipped in 1916. To take advantage of the high prices paid for galena in the fall of the year all the galena accumulated for several years was shipped. There is a 50-ton concentrating plant at the Commodore mine; and a 4 by 4 Chalmers & Williams ball mill, a Butchart sand table, 2 Overstrom sand tables, and a Deister slime table were added to the surface equipment.

The galena shipped by the Kentucky Fluorspar Co. came from various mines operated by the company and from purchased ore treated at a 30-ton plant by grinding and concentration. Blue & Nunn shipped a small quantity of galena from an open cut on the Nine Acre mine in Crittenden County in addition to a considerable output of zinc carbonate.

Sphalerite concentrates were recovered by Denny & Wilson, of Marion, Ky., from sands, low-grade ore, and slimes purchased in small quantities from various mines near Marion. The American Spar Co. operated the Hudson mine of the Eagle Fluorspar Co., near Salem, in Livingston County, and shipped most of the zinc carbonate. The ore was taken from an open cut about 50 feet in depth and treated in two double log washers before shipment. The Tabb mine of the Hoosier Mining Co., near Mexico, was operated by T. N. Fuller, who shipped zinc carbonate ore taken from shallow workings. No mining was done at the Blue Grass or Mann mines, near Lola, Ky., in 1916, but Langenbach & Morton and F. M. Bernard shipped zinc carbonate ore taken from dumps mined prior to 1916. The property of the Franklin Mining Co. near Marion was acquired by the Fairview Fluorspar & Lead Co., which built a small mill. The shaft at the mine is 300 feet deep and mining was resumed early in 1917.

## MICHIGAN.

By B. S. BUTLER.

### PRODUCTION.

In 1916 the mines of Michigan produced 273,692,525 pounds of copper, valued at $67,328,361, and 716,640 fine ounces of silver, valued at $471,549, a total value in copper and silver of $67,799,910. This is an increase of $21,078,251 in value over the production of 1915. Under the stimulus of high prices as large a production as possible was made throughout the year.

The average price of copper per pound for 1916 was $0.246; for 1915 it was $0.175. The average price of silver for 1916 was $0.658 per fine ounce; for 1915 it was $0.507. Owing to the increase in the price of copper and to the slight increase in copper recovered per ton, there was an increase from $3.76 in 1915 to $5.48 in 1916 in the average value per ton of "rock" treated.

The smelter production or the output of refined copper for 1916 was 269,794,531 pounds, as compared with 238,956,410 pounds in 1915. The difference between the mine and the smelter production is due to the fact that the quantity of "mineral" produced is not the same as the quantity smelted. A company may produce either more or less "mineral" than it smelts during the year.

*Value of silver and copper produced at Michigan mines in 1915 and 1916.*

| Year. | Silver. | Copper. | | Combined silver and copper. |
|---|---|---|---|---|
| | | Total. | Per ton of "rock." | |
| 1915 | $297,068 | $46,424,591 | $3.76 | $46,721,659 |
| 1916 | 471,549 | 67,328,361 | 5.34 | 67,799,910 |
| Increase | 174,481 | 20,903,770 | 1.58 | 21,078,251 |

The entire Michigan output of copper and silver is from the Keweenaw district. Both metals occur native in lodes remarkable for their great extent and uniformity. These lodes may be divided into two general classes—the amygdaloid, in which the metals occur together with gangue minerals, such as epidote, calcite, and zeolites, in the cellular portions of lava flows; and the conglomerate, in which the metals and gangue minerals cement and to some extent replace the pebbles forming the conglomerate. Native copper and copper minerals occur in fissures in the district, but the present output from this type of deposit is of little importance. The "rock"[1] is of low grade and requires milling, which produces "mineral" carrying an average of about 65 per cent copper. A small quantity of "barrel" and "mass" copper is sorted at the mines and sent direct to the smelters.

[1] Some of the terms used to designate the different materials entering into the mining industry differ for the Lake district from those employed in any other part of the country. Ore is known as "rock," or (if unmined) "copper ground"; the product of concentration is known as "mineral"; and the term "ore" is used to designate the copper minerals (arsenides and sulphides) that occur to a limited extent in the district. Large bodies of native copper are known as "mass" and smaller ones are designated as "barrel work." In this report the local terms will be used, as it does not seem desirable to employ the more usual terms to the exclusion of the local, and a mixture of the two is confusing.

In 1916 there were 12,364,114 short tons of "rock" milled, which yielded 436,977,306 pounds of "mineral" and 273,692,525 pounds of copper.[1]

The average recovery of refined copper per ton of "rock" milled in 1916 was 21.7 pounds, as compared with 21.5 pounds in 1915.

There were 716,640 ounces of silver derived from the electrolytic treatment of 63,635,475 pounds of copper. This electrolytic copper was recovered from approximately 2,175,000 tons of "rock," an average of 0.33 fine ounces of silver per ton of "rock."

*Mine production of silver, copper, "mineral," and "rock" in Michigan in 1915 and 1916.*

| Year. | Silver (fine ounces). | Copper. | | | "Mineral." | | "Rock" (short tons). |
|---|---|---|---|---|---|---|---|
| | | Quantity (pounds). | Yield. | | Quantity (pounds). | Yield (per cent). | |
| | | | Pounds per ton of "rock." | Per cent. | | | |
| 1915 | 585,933 | 265,283,378 | 21.5 | 1.08 | 400,178,132 | 66.29 | 12,334,700 |
| 1916 | 716,640 | [a] 273,692,525 | 21.7 | 1.08 | [b] 436,977,306 | 62.63 | 12,364,114 |
| Increase or decrease | +130,707 | +8,409,147 | +0.2 | ..... | +36,799,174 | −3.66 | +29,414 |

[a] Includes copper from sands. [b] Includes "mineral" from sands.

Three counties, Houghton, Keweenaw, and Ontonagon, contributed to the output of copper and silver. The following table shows the relative importance of these counties in output of copper and silver for 1915 and 1916:

*Mine production of silver and copper in Michigan for 1915 and 1916, by counties.*

1915.

| County. | Silver (fine ounces). | Copper. | | | "Mineral." | | "Rock" (short tons). |
|---|---|---|---|---|---|---|---|
| | | Quantity (pounds). | Yield. | | Quantity (pounds). | Yield (per cent). | |
| | | | Pounds per ton of "rock." | Per cent. | | | |
| Houghton | 511,224 | 207,624,783 | 22.1 | 1.10 | 316,867,891 | 65.5 | 9,415,042 |
| Keweenaw | 74,709 | 47,726,865 | 20.6 | 1.03 | 67,504,365 | 70.7 | 2,313,368 |
| Ontonagon | ..... | 9,931,730 | 16.4 | .82 | 15,805,876 | 62.8 | 606,290 |
| Total and average | 585,933 | 265,283,378 | 21.5 | 1.08 | 400,178,132 | 66.3 | 12,334,700 |

1916.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Houghton | 562,295 | [a] 213,109,436 | 22.4 | 1.12 | [b] 346,927,476 | 61.4 | 9,266,357 |
| Keweenaw | 78,667 | 48,195,482 | 20.1 | 1.00 | 70,597,440 | 68.3 | 2,395,517 |
| Ontonagon | 75,678 | 12,387,607 | 17.6 | .88 | 19,452,390 | 63.7 | 702,240 |
| Total and average | 716,640 | 273,692,525 | 21.7 | 1.08 | 436,977,306 | 62.6 | 12,364,114 |

[a] Includes copper from sands. [b] Includes "mineral" from sands.

[1] The figures are based on the actual recovery of copper from "mineral" smelted and the estimated recovery from "mineral" that was not smelted during 1916.

In the following reviews of the operations at the individual mines of the district during 1916, the statements concerning the quantity, character, and tenor of "rock" developed, the quantity of rock stamped, the copper recovered per short ton of rock stamped, and the cost of production are based on the published reports of the companies. In the few cases in which reports are not published a general statement of the character of operations is made from the best information available.

## HOUGHTON COUNTY.

In 1916 the mines of Houghton County produced 213,109,436 pounds of copper and 562,295 ounces of silver. The county occupies the central portion of the copper belt and contains 15 of the 22 mines that produced copper in 1916 and 6 of the 10 mines that produced silver.

*"Rock" and "mineral" produced and average yield in silver and copper in Houghton County in 1915 and 1916.*

| Year. | Silver (fine ounces). | Copper. | | | "Mineral." | | "Rock" (short tons). |
|---|---|---|---|---|---|---|---|
| | | Quantity (pounds). | Yield. | | Quantity (pounds). | Yield (per cent). | |
| | | | Pounds per ton of "rock." | Per cent. | | | |
| 1915 | 511,224 | 207,624,783 | 22.1 | 1.10 | 316,867,891 | 65.5 | 9,415,04[illegible] |
| 1916 | 562,295 | [a] 213,109,436 | 22.4 | 1.12 | [b] 346,927,476 | 61.4 | 9,266,357 |

[a] Includes copper from sands. [b] Includes "mineral" from sands.

The output of the county shows an increase of 5,484,653 pounds of copper and of 51,071 fine ounces of silver for 1916.

*Calumet & Hecla.*—The Calumet & Hecla Mining Co. has been one of the most successful copper mining companies in the world. To the close of 1916 the company had distributed $136,750,000 in dividends.

The company's ground contains three copper-bearing lodes—the Calumet & Hecla conglomerate, the Osceola amygdaloid, and the "Kearsarge" amygdaloid. A large percentage of the production in the past has come from the conglomerate lode, but with the decrease in copper content of this lode and its approaching exhaustion, the mining from the amygdaloid lodes has increased.

The company's annual report shows the details of operation for 1916 as follows:

During 1916 there were 3,166,274 short tons of "rock" treated, yielding 71,349,591 pounds of copper, or an average of 22.53 pounds of copper per ton of "rock." This compares with a yield of 22.28 pounds for 1915. The total cost per pound of copper was 11.63 cents for 1916, as compared with 9.33 cents for 1915. In addition to the copper recovered from ore mined 5,412,649 pounds were recovered from old sands from Torch Lake, making a total output of 76,762,240 pounds.

The conglomerate lode is opened for a distance of nearly 2 miles along its strike by 10 inclined shafts and 1 vertical shaft. The inclined shafts vary in depth on the dip of the lode from 6,102 to 8,132 feet. The Red Jacket vertical shaft has a depth of 4,900 feet.

In 1916 the conglomerate lode produced 1,727,794 tons of "rock," yielding 51,785,016 pounds of copper, or an average of 29.97 pounds per ton of "rock," as compared with 29.74 pounds for 1915.

The cost of producing copper from the conglomerate lode in 1916 was 10.75 cents per pound, as compared with 8.69 cents in 1915.

The Osceola lode is developed by 6 shafts, varying in depth from 1,460 to 2,958 feet. The lode has an average width of 30 to 35 feet, though at some points it is much wider. The mineralization is confined principally to the hanging and the foot walls. The lode is opened by drift stopes along the hanging wall, where the mineralization is rather uniform. Crosscuts are extended to the footwall, where the mineralization is far less regular. During 1916 this lode produced 1,438,480 tons of "rock," yielding 19,564,575 pounds of copper, or 13.6 pounds per ton of "rock." This compares with a yield of 13.32 pounds for 1915. The average cost per pound of copper from this lode for 1916 was 11.84 cents, as compared with 9.71 cents for 1915.

The Kearsarge lode is opened by 3 shafts, varying in depth from 1,350 to 2,291 feet. Development on this lode in Calumet & Hecla ground has not been encouraging, though the lode has proved very productive farther north. There was no output from the Kearsarge lode in 1916.

The recrushing plants treated 547,286 tons of coarse current tailings containing an average of 13.98 pounds of copper per ton; 2,289,797 pounds of copper were recovered, or an average of 4.18 pounds per ton of tailings treated. The cost per pound of copper recovered, exclusive of smelting and selling, was 5.51 cents.

The reclamation plant for treating old tailings from Torch Lake treated 545,727 tons, having an average copper content of 21.06 pounds per ton. A total of 5,412,649 pounds of copper was recovered, or an average of 9.92 pounds per ton, at an average cost, exclusive of smelting and selling, of 4.58 cents per pound.

The 2,000-ton leaching plant to treat tailings from the regrinding plant was partly completed during the year and part was placed in operation in July. The cost of the copper thus produced was less than 6 cents per pound. The operations were so successful that an additional 2,000-ton capacity has been contracted for.

*Tamarack.*—The Tamarack ground lies northwest of the Calumet & Hecla, and its operations are conducted on the underlays of the Calumet & Hecla conglomerate and the Osceola amygdaloid. Both lodes enter the property at considerable depth and are reached by vertical shafts, the different levels being connected with these shafts by crosscuts. The property is opened by 5 shafts, varying in depth from 3,409 feet (No. 1) to 5,308.5 feet (No. 5).

The company, although at a disadvantage on account of the great depth of the mine and the consequent high mining costs, has made a good record in dividends, which from 1888 to 1907 aggregated $9,420,000. Since the decline in the price of copper in 1907, however, the company has been unable to show a profit until 1912, when

relatively high prices again prevailed and copper was produced at a profit, and again in 1915. No report was issued by the company in 1916.

The average cost per pound of production during the five years 1911 to 1915 has been 15.56 cents for 1911, 13.15 cents for 1912, 16.60 cents for 1913, 29.08 cents for 1914, and 17.07 cents for 1915.

During 1915 217,027 tons of "rock" were stamped, yielding 6,139,824 pounds of "mineral" and 3,888,150 pounds of copper, or 17.9 pounds of refined copper per ton of "rock" stamped. This compares with a yield of 19.1 pounds in 1911, 18.8 pounds in 1912, 18.3 pounds in 1913, and 18.7 pounds in 1914.

*Osceola.*—In 1916 the Osceola Co. operated the three branches—the Osceola, the South Kearsarge, and the North Kearsarge. Since 1878 this company has distributed dividends to the amount of $15,064,175.

The Osceola branch lies directly south of the Calumet & Hecla, and is worked on the Osceola amygdaloid. The property contains the Calumet & Hecla conglomerate lode, but the only portion of it in Osceola ground that has been shown to carry copper in paying quantities was worked out in the early days of the mine.

A total of 225,030 tons of "rock" was produced in 1916, yielding 3,350,014 pounds of copper, or an average of 14.89 pounds per ton, at a cost of 15.46 cents per pound.

The North Kearsarge lies north of the Wolverine, and is worked on the Kearsarge lode. No. 1 shaft has a depth of 4,091 feet, No. 3 shaft has a depth of 3,403 feet, and No. 4 shaft has a depth of 1,622 feet. A total of 4,107 feet of opening was accomplished on this branch in 1916. This branch produced 651,079 tons of "rock," yielding 9,267,738 pounds of copper, or an average of 14.23 pounds per ton, at a cost of 11.72 cents per pound.

The South Kearsarge lies south of the Wolverine and east of the Centennial on the Kearsarge lode. No. 1 shaft has a depth of 2,820 feet and No. 2 shaft has a depth of 1,992 feet.

This branch produced 408,572 tons of "rock," yielding 6,968,749 pounds of copper, or an average of 17.06 pounds per ton, at a cost of 9.47 cents per pound.

In 1916 the company treated 1,284,681 tons of "rock," producing 26,901,015 pounds of "mineral" and 19,586,501 pounds of copper, an average yield of 15.2 pounds of refined copper per ton of "rock." This compares with a yield of 14.5 pounds in 1915. The total cost of refined copper per pound was 11.69 cents for 1916, as compared with 10.03 cents in 1915.

Dividends were declared in 1916 to the amount of $1,826,850.

*Centennial.*—The Centennial ground lies north of the Calumet & Hecla and west of the South Kearsarge and the Wolverine. It contains the Calumet & Hecla, the Osceola, and the Kearsarge lodes the last being the only one of proved value in the property, and to this lode operations are at present confined.

At the close of 1916 the depth of No. 1 shaft was 4,000 feet. Shaft No. 2 had a depth of 4,293 feet at the close of 1916. A total of 2,208 feet of development was accomplished at this shaft.

"Rock" to the amount of 150,617 tons was stamped during the year, producing 2,369,400 pounds of refined copper, or 15.72 pounds of

refined copper per ton of "rock" stamped. The average cost of refined copper per pound was 13.44 cents, as compared with 12.45 cents for 1915.

*Wolverine.*—The Wolverine is located between the North Kearsarge and the South Kearsarge branches of the Osceola Co. Its operations are on the "Kearsarge" amygdaloid, though the West lode, parallel with the Kearsarge lode and about 80 feet to the west, has been opened to a small extent. The mine has the distinction of having the richest amygdaloid and, next to the Calumet & Hecla conglomerate, the richest rock, mined in the district. The Kearsarge lode is opened by 5 shafts, numbered from 1 to 5, from north to south; No. 1 is abandoned; No. 2, bottomed at the boundary at a depth of 1,700 feet, is used for handling men and supplies; No. 3 has attained a depth of 4,005 feet and can be sunk to a depth of 4,300 feet before reaching the boundary; No. 4 has a depth of 4,180 feet; No. 5 was sunk to a depth of 631 feet on the Osceola lode. The operations on the Osceola lode have thus far proved disappointing. The Kearsarge lode in the Wolverine ground shows great uniformity of mineralization, and is opened for the full length. In the upper levels the "rock" averaged from 16 to 18 pounds per ton, but as the lower levels were opened it showed marked improvement. As the bottom limits are approached there is a notable decrease in the copper content of the rock.

During the fiscal year ending June 30, 1916, there were stamped 388,898 tons of "rock," producing 9,127,790 pounds of "mineral," yielding 6,641,492 pounds of copper, or 17.07 pounds of refined copper per ton of "rock" stamped. The total cost per pound of refined copper was 9.54 cents.

Since its organization to June 30, 1916, the company has produced 151,303,110 pounds of copper. Operations have resulted in profits amounting to $9,622,528, of which $8,760,000 has been paid in dividends. Two dividends paid during the fiscal year amounted to $660,000.

*Franklin.*—The Franklin and the Rhode Island, which is controlled by the Franklin, are located southeast of the La Salle. The property carries several lodes, but in the past exploration has been principally on the "Pewabic" amygdaloid and the Allouez or "Albany and Boston" conglomerate.

An output of 267,286 tons of "rock" stamped yielded 3,116,566 pounds of copper.

*Quincy.*—The Quincy mine is situated just north of the east-west arm of Portage Lake. The property is traversed by most of the lodes of the district, but has derived its principal output in the past from the Pewabic lode, with a small quantity from the West lode.

Dividends to the amount of $1,760,000 were paid in 1916. The total disbursement in dividends from 1862 to 1916 is $23,537,500.

In 1916 there were mined 1,204,026 tons of "rock," which yielded 33,864,280 pounds of "mineral" and 21,065,612 pounds of copper, an average of 17.5 pounds per ton of rock.

*Isle Royale.*—The Isle Royale mine is situated south of the east-west arm of Portage Lake, near Houghton. The property contains several copper-bearing lodes, of which the Isle Royale is the main producer at present.

A total of 17,455 feet of openings was accomplished during 1916.

During 1916 "rock" amounting to 925,419 tons was treated, yielding 12,412,111 pounds of copper, or an average of 13.4 pounds of copper per ton. The average cost per pound of copper was 15.32 cents as compared with 14.52 cents in 1915.

Dividends were paid to the amount of $750,000.

*Baltic, Champion, and Trimountain.*—These three mines are located on the Baltic lode southwest of Houghton and are under the same management as the Copper Range Consolidated Co. The Baltic is an exceptionally strong lode, having a stoping width varying from 15 to 80 feet. The lode has produced considerable "mass" copper, and also contains veinlets of copper minerals, including chalcocite, bornite, and copper arsenides. These minerals are recovered in the mill, and the arsenides probably account in part for the arsenical character of the Copper Range output.

During 1916 the Baltic operated three shafts with depths of 2,773 feet for No. 2, 3,103 feet for No. 3, and 2,867 feet for No. 4.

A total of 369,287 tons of "rock" was stamped, producing 12,425,804 pounds of refined copper, or 33.65 pounds of refined copper per ton of "rock" stamped. The cost per pound of refined copper was 10.85 cents.

Since its organization to the close of 1916 the Baltic company has produced 200,584,166 pounds of copper at a profit of $11,183,184, of which $7,950,000 has been distributed as dividends.

The Trimountain is also opened by three shafts, with depths of 2,859 feet for No. 2, 2,563 feet for No. 3, and 2,715 feet for No. 4, at the close of 1916. Openings made during the year showed about average values.

A total of 349,504 tons of "rock" was stamped, yielding 8,720,558 pounds of refined copper, or an verage of 24.94 pounds per ton. The average cost per pound of copper was 11.10 cents.

Since its organization the company has produced 110,530,028 pounds of copper at a profit of $3,942,088, of which $1,450,000 has been disbursed as dividends.

The Champion, controlled jointly by the Copper Range Consolidated Co. and the St. Mary's Mineral Land Co., is opened by 4 shafts with depths varying from 2,239 to 2,514 feet.

A total of 936,656 tons of "rock" was stamped, yielding 33,601,136 pounds of refined copper, a yield of 35.87 pounds per ton of "rock" stamped. The cost of refined copper per pound was 7.80 cents.

From its organization to the close of 1916 the Champion company has produced 258,873,210 pounds of copper at a profit of $19,186,473, of which $17,514,540 has been disbursed as dividends.

*Superior.*—The Superior is northeast of the Baltic. The ground on this property is being opened by 2 shafts, and at the close of 1916 No 1 shaft had reached a depth of 2,906 feet and No. 2 a depth of 1,628 feet.

During the year 185,315 tons of "rock" were stamped, producing 3,034,656 pounds of copper, or 16.38 pounds per ton of "rock" stamped. The cost of copper a pound was 13.78 cents.

The first dividend of $100,000 was paid in 1916.

*La Salle.*—The La Salle company produced 144,829 tons of "rock," yielding 1,380,352 pounds of copper, or an average of 9.53 pounds per ton of "rock." The net cost per pound of copper was 19.96 cents.

*Winona.*—The Winona produced 161,828 tons of "rock," which yielded 3,700,180 pounds of "mineral" and 2,167,255 pounds of refined copper, an average of 13.39 pounds or refined copper per ton of "rock" stamped.

The cost of copper was 28.03 cents per pound.

*Hancock.*—The Hancock Consolidated Mining Co. treated 203,112 tons of "rock," which yielded 2,824,934 pounds of refined copper, an average of 13.9 pounds per ton.

*New Arcadia.*—The New Arcadia Copper Co. treated 1,391 tons of "rock" at the Franklin mill, yielding 32,307 pounds of refined copper.

*Other companies.*—Other companies were active in development work.

## KEWEENAW COUNTY.

In 1916 Keweenaw County produced 48,195,482 pounds of copper and 78,667 fine ounces of silver. The county occupies the northern portion of the copper belt.

*"Rock" and "mineral" produced and average yield in silver and copper in Keweenaw County in 1915 and 1916.*

| Year. | Silver (fine ounces). | Copper. | | | "Mineral." | | "Rock" (short tons). |
|---|---|---|---|---|---|---|---|
| | | Quantity (pounds). | Yield. | | Quantity (pounds). | Yield (per cent). | |
| | | | Pounds per ton of "rock." | Per cent. | | | |
| 1915 | 74,709 | 47,726,865 | 20.6 | 1.03 | 67,504,365 | 70.7 | 2,313,368 |
| 1916 | 78,667 | 48,195,482 | 20.1 | 1.00 | 70,597,440 | 68.3 | 2,395,517 |

*Ahmeek.*—The Ahmeek mine, lying north and east of the Allouez, is located on the Kearsarge lode. The lode is opened by 4 shafts; No. 1 has a depth of 2,720 feet; No. 2, a depth of 2,971 feet; No. 3, 2,473 feet; and No. 4, 2,319 feet.

A total of 1,164,010 tons of "rock" were stamped, yielding 24,142,158 pounds of refined copper, or 20.7 pounds of refined copper per ton of "rock." The total cost per pound of refined copper was 11.47 cents.

During the year dividends were declared to the amount of $2,800,000. Total dividends to the close of 1916 amounted to $6,850,000.

*Allouez.*—The Allouez mine is north of the North Kearsarge, and, as in recent years, operations were confined to the Kearsarge lode. As this lode does not outcrop on Allouez property, the shafts were started in the hanging wall at a steep angle and flattened to the dip of the copper-bearing bed just before reaching it. This plan avoids the expense of long crosscuts necessitated by vertical shafts.

A total of 566,960 tons of "rock" was stamped during 1916, yielding 10,219,290 pounds of refined copper, an average of 18.02 pounds of refined copper per ton of "rock." The total cost per pound of refined copper was 10.47 cents.

Dividends declared during the year amounted to $900,000. Total dividends to April, 1917, amounted to $1,400,000.

*Mohawk.*—The Mohawk mine, lying east of the Ahmeek, carries the outcrop of the Kearsarge lode for more than a mile and also contains several cross fissures carrying arsenides of copper, which have been mined to a considerable extent in the past. Operations were conducted through 6 shafts.

A total of 664,547 tons of "rock" was stamped, yielding 18,468,100 pounds of "mineral," and 13,834,034 pounds of copper, or an average of 20.82 pounds per ton of "rock." The total cost per pound of refined copper was 8.85 cents.

Since organization the Mohawk company has produced 147,140,915 pounds of copper, at a profit of $7,908,839, of which amount $5,575,000 has been disbursed as dividends.

*Keweenaw.*—The Keweenaw Copper Co. treated 6,915 tons of "rock," yielding 105,694 pounds of "mineral" and 68,880 pounds of copper, or 9.96 pounds per ton of "rock."

## ONTONAGON COUNTY.

In 1916, Ontonagon County produced 12,387,607 pounds of copper. Ontonagon County contains the southwestern portion of the copper belt. This portion has not been so thoroughly developed as the others and consequently the geology is less understood than in the more northern counties. So far as developed, the lodes are more "bunchy" than to the north and have produced a relatively high percentage of mass copper. The production of 1916 was derived wholly from amygdaloid rock.

*"Rock" and "mineral" produced and average yield in copper in Ontonagon County in 1915 and 1916.*

| Year. | Silver (fine ounces). | Copper. | | | "Mineral." | | "Rock" (short tons). |
|---|---|---|---|---|---|---|---|
| | | Quantity (pounds). | Yield. | | Quantity (pounds). | Yield (per cent). | |
| | | | Pounds per ton of "rock." | Per cent. | | | |
| 1915 | ..... | 9,931,730 | 16.4 | 0.82 | 15,805,876 | 62.8 | 606,290 |
| 1916 | 75,678 | 12,387,607 | 17.6 | .88 | 19,452,390 | 63.7 | 702,240 |

*Mass.*—The Mass mine, adjoining the Adventure on the southwest, carries six known copper-bearing amygdaloid lodes—the Knowlton, the Mass, the North Butler, the Butler, the Ogima, and the Evergreen. In addition, the position of the property makes it probable that the newly discovered lodes in this part of the district may be present in the Mass ground. The main developments for the year were from "B" and "C" shafts on the Butler and Evergreen lodes, and continued to show as satisfactory conditions with respect to copper values as in previous years.

A total of 287,900 tons of "rock" was stamped in 1916, yielding 7,314,630 pounds of "mineral" and 4,752,588 pounds of refined copper, an average of 16.51 pounds of refined copper per ton of "rock" stamped.

The average cost of refined copper (including costs of construction) was 15.37 cents per pound.

*Victoria.*—The Victoria is the most southwesterly of the Lake mines that have made important production. The first attempts at copper mining in the district are said to have been made at this locality, though its recent period of productiveness began in 1906. The present production is from the Forest lode. "Rock" amounting to 146,690 tons was stamped, yielding 2,568,396 pounds of "mineral" and 1,661,832 pounds of copper.

*White Pine Copper Co.*—The White Pine Copper Co. treated 188,890 tons of "rock," yielding 4,207,449 pounds of copper, at a cost per pound of 11.22 cents.

The Lake mine produced again in 1916. The Michigan Copper Co. shipped 90,000 pounds of mass copper, and the Adventure Consolidated Copper Co. shipped some "rock" to the Winona mill.

The South Lake Mining Co. shipped to the Franklin mill 20,057 tons of "rock," which with "mass" copper yielded 285,600 pounds of copper. Other companies were active in exploration and development.

## MISSOURI.

By J. P. DUNLOP.

### PRODUCTION.

#### VALUE.

The value of the mine production of recoverable silver, copper, lead, and zinc in Missouri in 1916 was $74,143,607, compared with $53,683,420 in 1915. The value of the copper production showed an increase of $24,627, that of silver $55,896, that of lead $12,384,784, and that of zinc $7,994,880, so that the large increase in the total value was caused mainly by the much larger output and the higher average price of lead and zinc in 1916, compared with 1915. The recoverable lead content of Missouri lead concentrates sold in 1916 was equal to 39 per cent of the smelter production of primary lead in the United States derived from domestic ores, and the recoverable spelter content from Missouri zinc concentrates sold in 1916 was 28 per cent of the primary spelter produced by smelters from domestic ores in 1916.

#### SILVER AND COPPER.

*Mine production of silver and copper in Missouri, 1910–1916.*

| Year. | Copper. | | Silver. | | Lead concentrates, silver-bearing (short tons). |
|---|---|---|---|---|---|
| | Quantity (pounds). | Value. | Quantity (fine ounces). | Value. | |
| 1910 | 94,452 | $11,955 | 33,096 | $17,872 | 35,002 |
| 1911 | 640,411 | 80,051 | 49,867 | 26,430 | 51,109 |
| 1912 | 440,725 | 72,719 | 35,438 | 21,794 | 31,183 |
| 1913 | 576,204 | 89,312 | 35,620 | 21,514 | 35,854 |
| 1914 | 44,463 | 5,914 | 61,168 | 33,826 | 61,995 |
| 1915 | 402,160 | 70,378 | 57,756 | 29,282 | 64,377 |
| 1916 | 386,200 | 95,005 | 129,450 | 85,178 | 88,061 |

For several years prior to 1913 the entire silver production of Missouri had been derived from refining lead concentrates, but in each of the last four years a small quantity of silver was obtained from oxidized copper ore shipped from mines in Ste. Genevieve, Washington, and other counties. The quantities given in the fourth column of the foregoing table are those of recovered silver. The silver content of the lead ores is so small that it is disregarded in the assay and sale of the concentrates. For this reason the smelter reports must be relied upon for the silver production. As may be seen by inspection of the table, the quantity of silver produced in any year bears no direct ratio to the quantity of lead concentrates smelted during that year. The reason for this is that the silver content is so small in quantity that the silver bullion is stored and refined in batches. If a series of years be taken into account, the concentrates are seen to average about 1 ounce of silver to the ton.

The production of copper in Missouri in 1916 was 386,200 pounds, valued at $95,005, as compared with 402,160 pounds, valued at $70,378, in 1915. The North American mine, now owned by the Missouri Cobalt Co., which produced some copper as well as nickel and cobalt in the years 1908 and 1909, had no output in 1916. Nearly all the copper output for 1916 was derived from concentrates recovered in dressing lead ore mined in St. Francois County, in southeastern Missouri. Some copper ore was mined and shipped by the Swansea mine in Ste. Genevieve County and from the Racola mine in Washington County. In addition to the copper the ore is reported to have yielded some silver.

## LEAD AND ZINC.

The total value of the recoverable metallic content of the lead and zinc concentrates produced in Missouri in 1916 was $73,963,424, an increase of $20,379,664 over that of 1915. The production of lead concentrates in Missouri in 1916 (of which all but 27 tons was galena) was 347,869 short tons, valued at $24,172,965, as compared with an output of 312,567 tons, valued at $14,579,361, in 1915, an increase of 35,302 tons in quantity and of $9,593,604 in value. Of this production in 1916 of lead concentrates 307,025 tons, valued at $20,720,737, was derived from southeastern and central Missouri, an increase of 28,921 tons in quantity and of $7,947,158 in value. The average metal content of the lead concentrates from these districts was 65.66 per cent, as compared with 66.5 per cent in 1915, and the value per ton in 1916 was $67.47, an increase of $21.58. The quantity of recoverable lead in southeastern and central Missouri concentrates in 1916 amounted to 201,632 tons, an increase of 17,726 tons. The output was equal to about 34 per cent of the primary lead smelted or refined from domestic ores in the United States in 1916.

Shipments of lead concentrates from southwestern Missouri were 40,844 tons, valued at $3,452,228, as compared with 34,463 tons, valued at $1,805,782, in 1915. The lead carbonate concentrates amounted to 27 tons, valued at $1,660, a decrease of 188 tons. The quantity of recoverable lead from southwestern Missouri, or the Joplin region, was 31,456 tons, valued at $4,340,928, an increase of 4,922 tons. The average metal content of the galena concentrates

from southwestern Missouri was 77 per cent and the average price per ton was $84.54, or $32.02 more per ton than in 1915.

The quantity of zinc blende concentrates sold from Missouri mines in 1916 was 277,176 tons, valued at $22,878,215, an increase of 36,065 tons in quantity and of $4,495,695 in value, when compared with the figures for 1915. All the blende concentrate except 365 tons was produced in southwestern Missouri. The average price received per ton was $82.55 and the average recoverable zinc content reported by the sellers was 58.7 per cent. The average price paid per ton in 1915 was $76.24 and the average recoverable zinc content was 58.7 per cent.

The zinc content of the sphalerite concentrates derived from "sheet-ground" mines, which was 58.6 per cent in the years 1911 and 1912, declined to 58.3 per cent in 1913 and increased to 58.4 per cent in 1914, to 59.1 per cent in 1915, and to 59.2 per cent in 1916. The average price received for sphalerite concentrates in 1916 was $6.31 a ton more than in 1915.

The zinc carbonate and silicate concentrates sold in 1916 amounted to 26,894 tons, valued at $1,350,381. This was 1,482 tons more in quantity and $106,923 more in value than the sales in 1915. The output in 1916 was mainly from southwestern Missouri, the shipments from southeastern Missouri being only 1,030 tons, valued at $42,129, as compared with 1,061 tons, valued at $39,460, in 1915. The average metal content of the zinc carbonate and silicate concentrates was 39.4 per cent in 1916. The average value per ton in 1916 was $50.21 as compared with $45 in 1915.

The combined value of lead and zinc concentrates from southeastern and central Missouri in 1916 (which produced about 89 per cent of the lead concentrates) was $20,777,266, or $7,963,163 more than in 1915.

The total value of the southwestern Missouri lead and zinc concentrates was $27,624,295, as compared with $21,391,236 in 1915, an increase of $6,233,059.

The total quantity of crude ore or "dirt" mined and treated in 1916 amounted to 18,663,900 short tons, an increase of about 3,100,000 tons, or approximately 20 per cent more than the quantity mined and treated in 1915. As the total amount received for all classes of lead and zinc concentrates sold in 1915 was $48,401,561, the average value per ton of crude ore or "dirt" mined and treated was $2.60, compared with $2.20 in 1915, $1.65 in 1914, $1.72 in 1913, and $1.86 in 1912.

The small quantity of copper ore mined and shipped in 1916 is excluded from these calculations.

In the following tables showing the tenor of crude ore ("dirt") and concentrates from Missouri it has been considered advisable to segregate the ores of different nature. For instance, the disseminated lead ore of southeastern Missouri differs radically from the lead and zinc ores of the so-called "soft ground" deposits of southwestern Missouri, and these in turn differ from the "sheet ground" deposits of the same region. Each class of ore has its peculiar problems of mining and ore dressing. This fact makes desirable the separate treatment of the statistical data. In general, the tables reflect very closely the conditions of the industry.

*Production of lead and zinc in Missouri in 1916.*

| District. | Ores. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lead concentrates. | | | | Zinc concentrates. | | | |
| | Galena. | | Carbonate. | | Sphalerite. | | Silicate and carbonate. | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| Southwestern Missouri: | | | | | | | | |
| Alba-Neck City | 318 | $24,795 | ..... | ..... | 14,227 | $1,132,591 | 102 | $4,077 |
| Ash Grove-Everton | 67 | 5,025 | ..... | ..... | ..... | ..... | 1,968 | 73,700 |
| Aurora | 106 | 7,516 | 3 | $102 | 3,194 | 239,595 | 4,895 | 207,215 |
| Carl Junction | ..... | ..... | ..... | ..... | 681 | 55,502 | ..... | ..... |
| Carthage | 72 | 6,006 | ..... | ..... | 3,835 | 298,950 | 4 | 153 |
| Cave Springs | 412 | 32,717 | ..... | ..... | 2,595 | 225,062 | ..... | ..... |
| Diamond | 2 | 180 | ..... | ..... | 306 | 25,132 | 256 | 11,327 |
| Duenweg-Porto Rico | 6,538 | 532,995 | ..... | ..... | 40,709 | 3,354,375 | 1,302 | 73,954 |
| Fairview and Pioneer | ..... | ..... | ..... | ..... | 35 | 2,600 | 111 | 6,069 |
| Granby | 308 | 19,488 | ..... | ..... | 6,924 | 662,695 | 9,310 | 573,689 |
| Joplin | 5,949 | 492,383 | 2 | 97 | 51,259 | 4,279,912 | 3,339 | 154,907 |
| McDowell-Stark City | 51 | 4,600 | ..... | ..... | 300 | 27,000 | 137 | 6,617 |
| Oronogo | 3,062 | 259,150 | ..... | ..... | 11,300 | 830,025 | ..... | ..... |
| Sarcoxie-Reeds | 1 | 64 | ..... | ..... | 4,856 | 329,467 | 130 | 5,300 |
| Sherwood-Thoms Station | 615 | 52,692 | ..... | ..... | 4,721 | 310,287 | ..... | ..... |
| Spring City-Beef Branch | 340 | 27,492 | 22 | 1,461 | 834 | 65,187 | 1,723 | 92,646 |
| Springfield | 272 | 20,086 | ..... | ..... | 2,005 | 156,169 | ..... | ..... |
| Spurgeon-Seneca | 240 | 18,866 | ..... | ..... | 2,240 | 141,262 | 311 | 14,904 |
| Stott City | ..... | ..... | ..... | ..... | 573 | 48,324 | ..... | ..... |
| Webb City-Carterville-Prosperity | 22,231 | 1,930,295 | ..... | ..... | 113,835 | 9,751,555 | ..... | ..... |
| Wentworth | ..... | ..... | ..... | ..... | 4,991 | 348,217 | 960 | 39,000 |
| Zincite-Klondike | 139 | 9,618 | ..... | ..... | 7,278 | 573,128 | ..... | ..... |
| Christian County | 94 | 6,600 | ..... | ..... | 100 | 6,000 | 734 | 29,827 |
| Ozark, Howell, and Taney counties | ..... | ..... | ..... | ..... | 13 | 780 | 582 | 14,867 |
| | 40,817 | 3,450,568 | 27 | 1,660 | 276,811 | 22,863,815 | 25,864 | 1,308,252 |
| Central and southeastern Missouri | 307,025 | 20,720,737 | ..... | ..... | 365 | 14,400 | 1,030 | 42,129 |
| State total, 1916 | 347,842 | 24,171,305 | 27 | 1,660 | 277,176 | 22,878,215 | 26,894 | 1,350,381 |
| 1915 | 312,352 | 14,572,361 | 215 | 7,000 | 241,111 | 18,382,520 | 25,412 | 1,243,452 |

| District. | Metal content.[a] | | | |
|---|---|---|---|---|
| | Lead. | | Zinc. | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| Southwestern Missouri: | | | | |
| Alba-Neck City | 236 | $32,568 | 7,548 | $2,022,864 |
| Ash Grove-Everton | 52 | 7,176 | 645 | 172,800 |
| Aurora | 81 | 11,178 | 3,392 | 909,056 |
| Carl Junction | ..... | ..... | 373 | 99,964 |
| Carthage | 57 | 7,866 | 2,102 | 563,336 |
| Cave Springs | 317 | 43,746 | 1,391 | 372,788 |
| Diamond | 1 | 138 | 254 | 68,072 |
| Duenweg-Porto Rico | 5,015 | 692,070 | 22,079 | 5,917,172 |
| Fairview and Pioneer | ..... | ..... | 57 | 15,276 |

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses in zinc but not in lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily spot quotations at New York and the value of the zinc from the average sales price of all grades reported by smelters.

*Production of lead and zinc in Missouri in 1916*—Continued.

| District. | Metal content. | | | |
|---|---|---|---|---|
| | Lead. | | Zinc. | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| Southwestern Missouri—Continued. | | | | |
| Granby | 228 | $31,464 | 6,990 | $1,873,320 |
| Joplin | 4 566 | 630,108 | 28.363 | 7,601,284 |
| McDowell-Stark City | 41 | 5,658 | 206 | 55.208 |
| Oronogo | 2,401 | 331,338 | 5,952 | 1,595,136 |
| Sarcoxie-Reeds | 1 | 138 | 2,717 | 728,156 |
| Sherwood-Thoms Station | 496 | 68,448 | 2,295 | 615,060 |
| Spring City-Beef Branch | 278 | 38,364 | 1,040 | 278,720 |
| Springfield | 221 | 30,498 | 1.123 | 300,964 |
| Spurgeon-Seneca | 187 | 25,806 | 1,247 | 334,196 |
| Stott City | | | 315 | 84,420 |
| Webb City-Carterville-Prosperity | 17,100 | 2,359,800 | 60,341 | 16,171,388 |
| Wentworth | | | 2,819 | 755,492 |
| Zincite-Klondike | 106 | 14,628 | 3,793 | 1,016,524 |
| Christian County | 72 | 9,936 | 303 | 81.204 |
| Ozark, Howell, and Taney counties | | | 182 | 48,776 |
| | 31,456 | 4,340,928 | 155 527 | 41,681.236 |
| Central and southeastern Missouri | 201,632 | 27,825,216 | 433 | 116,044 |
| State total, 1916 | 233,088 | 32,166,144 | 155,960 | 41,797,280 |
| 1915 | 210,440 | 19,781,360 | 136,300 | 33,802 400 |

*Tenor of crude lead and zinc ore and concentrates produced in southwestern Missouri in 1915 and 1916.*[a]

| | 1915 | 1916 |
|---|---|---|
| SOFT GROUND. | | |
| Total crude ore.....short tons | 4,004,900 | 4,711,700 |
| Total concentrates in crude ore.....per cent | 3.88 | 3.38 |
| Lead.....do | .32 | .28 |
| Zinc.....do | 3.56 | 3.10 |
| Metal content of crude ore.....do | 2.26 | 1.92 |
| Lead.....do | .25 | .22 |
| Zinc.....do | 2.01 | 1.70 |
| Average lead content of galena concentrates.....do | 79.2 | 78.0 |
| Average lead content of lead carbonate concentrates.....do | 58.1 | 55.5 |
| Average zinc content of sphalerite concentrates.....do | 57.7 | 58.1 |
| Average zinc content of silicates and carbonates.....do | 39.3 | 39.4 |
| Average value per ton: | | |
| Galena concentrates | $48.19 | $82.09 |
| Lead carbonate concentrates | $32.56 | $61.48 |
| Sphalerite concentrates | $72.68 | $77.94 |
| Zinc silicates and carbonates | $45.00 | $50.21 |
| SHEET GROUND. | | |
| Total crude ore.....short tons | 6,501,000 | 8,484,700 |
| Total concentrates in crude ore.....per cent | 2.25 | 2.19 |
| Lead.....do | .34 | .33 |
| Zinc.....do | 1.91 | 1.86 |
| Metal content of crude ore.....do | 1.38 | 1.35 |
| Lead.....do | .25 | .25 |
| Zinc.....do | 1.13 | 1.10 |
| Average lead content of galena concentrates.....do | 76.4 | 76.5 |
| Average content of sphalerite concentrates.....do | 59.1 | 59.2 |
| Average value per ton: | | |
| Galena concentrates | $54.63 | $85.62 |
| Sphalerite concentrates | $78.79 | $86.02 |

[a] Including also the small production of lead and zinc ores in southeastern and central Missouri.

*Tenor of crude lead ore and concentrates in southeastern Missouri disseminated lead ore in 1915 and 1916.*

| | | 1915 | 1916 |
|---|---|---|---|
| Total crude lead ore | short tons | 5,067,800 | 5,467,500 |
| Galena concentrates in crude ore | per cent | 5.47 | 5.60 |
| Lead content in crude ore | do | 3.62 | 3.68 |
| Average lead content of galena concentrates | do | 66.5 | 65.66 |
| Average value per ton of galena concentrates | | $45.89 | $67.47 |

In Mineral Resources for 1914, volume 1, pages 72–77 and 97–100, was given a brief history of lead and zinc mining in the southeastern Missouri and Joplin regions, together with data relating to the total lead and zinc production, the mining and milling practice, and the methods of selling ore and concentrates. The separate chapter entitled "Silver, copper, lead, and zinc in the Central States in 1914" is available for distribution and can be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

## SOUTHWESTERN MISSOURI.

### AREA, ORES, DEPOSITS.

The southwestern Missouri lead and zinc area includes the largest part of the Joplin region, the remaining portion lying in southeastern Kansas and in northeastern Oklahoma. The Missouri part of the region was first developed, then that in Kansas, followed at a considerably later period by Oklahoma.

The ore in southwestern Missouri occurs in the Mississippian Boone limestone, in beds of Kinderhook age. The ore deposits are found in Jasper, Newton, Lawrence, Greene, and adjoining counties. This area produced in 1916 more than four-fifths of the lead and zinc ore mined in the Joplin region.

The lead ores are galena, with a small quantity of lead carbonate, locally known as "dry bone." The zinc ores are sphalerite, or zinc blende, or "jack," zinc carbonate (smithsonite), and zinc silicate (calamine), both of the latter locally called "silicate." The galena contains but a small fraction of an ounce of silver to the ton of lead concentrates, and although ordinarily it is not desilverized, yet occasionally the refineries find it advantageous to add lead from the Joplin region to their charges without, however, making any record of the silver content. In this way an unknown but small quantity of silver is recovered from southwestern Missouri lead ore. The zinc ores, sphalerite, smithsonite, and calamine contain notable quantities of cadmium, being fully as rich in this respect as the zinc ores of Silesia, which are the source of the cadmium production of Europe. The discussion of the cadmium content of these ores is taken up more fully in the chapter entitled "Cadmium," in Mineral Resources for 1908.

The ore deposits of the Joplin district vary in character with the depth of mining. The shallower ores beginning at the surface are universally pockety and are found in residual clays or in "runs" in the basal breccias of the region. The breccias and the forms of the

"runs" are largely, if not altogether, due to solution of the limestone strata. One form of run, which is fairly numerous, is the "circle" deposit, which, in the popular view, has come to be nearly synonymous with rich deposits. Small veins, vertical sheets, and thin crevice deposits are often met with in prospecting, but unless they develop into stringers leading into paying ore bodies are forgotten in the multitude of rich pockety deposits which the district has yielded. The blanket deposits or "sheet ground" are found in the Grand Falls chert member of the Boone limestone at depths varying from 100 to 275 feet, depending on the topography and the geologic structure. Below this horizon there are, in the beds of Kinderhook age, deposits of disseminated ore. They have been found in prospect shafts or drill holes near Springfield, Aurora, Granby, Carterville, Joplin, Hornet, and Cave Springs, in Missouri; at Galena, in Kansas; and at Quapaw, in Oklahoma.

*Lead and zinc concentrates produced in the Missouri part of the Joplin region, 1907–1916.*

| | Quantity (short tons). | Value. |
|---|---|---|
| Lead concentrates | 368,516 | $21,221,471 |
| Sphalerite concentrates | 2,277,934 | 113,590,183 |
| Zinc carbonate and silicate concentrates | 218,996 | 6,509,499 |
| | 2,865,446 | 141,321,153 |

The average price per ton received for sphalerite concentrates during the period 1907 to 1916 was $49.86, and that for zinc silicate and carbonate was $29.73.

## ASSAYS.

Several of the assayers in the Joplin district make a practice of saving the remnants of blende samples analyzed during the year. At the close of the year the lot is thoroughly mixed and carefully sampled, from which sample an average or composite assay for the year is made. Each assay thus represents several thousand lots. Two representative series of such composite assays are given below. In most cases each sample included in the composite assay represents a carload lot of concentrates.

The first series, by W. W. Petraeus and Evans W. Buskett, of Joplin, gives the result of analyses of composite samples from the general district for the last 16 years. The analyses for 1897–1905, inclusive, were published in the Lead and Zinc News, volume 9, page 8, January 15, 1906. The analyses for 1906–1913 were kindly communicated by Mr. Petraeus and those for 1914–1916 by Mr. Buskett. Iron was not taken into account until 1900. Some 400 scattering assays, made in 1895–96, are excluded from the table.

*Composite assays of zinc blende from the Joplin region, 1897–1916.*

[W. W. Petraeus, analyst, 1897–1913; Evans W. Buskett, analyst, 1914–1916.]

| Year. | Number of lots in the composite. | Percentage. | | | | |
|---|---|---|---|---|---|---|
| | | Zinc. | Iron. | Lead. | Copper. | Cadmium. |
| 1897 | 600 | 56.64 | | | | |
| 1898 | 1,299 | 56.99 | | | | |
| 1899 | 3,715 | 56.67 | | | | |
| 1900 | 3,500 | 57.36 | 0.22 | | | |
| 1901 | 3,683 | 57.53 | 2.02 | | | |
| 1902 | 5,776 | 57.08 | 2.24 | | | |
| 1903 | 6,014 | 57.30 | 2.00 | | | |
| 1904 | 6,220 | 57.24 | 2.10 | | | |
| 1905 | 4,628 | 57.97 | 1.84 | 1.00 | 0.001 | 0.198 |
| 1906 | 5,644 | 57.2 | 2.00 | | | |
| 1907 | 6,813 | 56.8 | 1.93 | | | |
| 1908 | 7,837 | 56.4 | 1.76 | | | |
| 1909 | 9,002 | 56.3 | 2.00 | | | |
| 1910 | 8,892 | 56.6 | 2.10 | 1.02 | .06 | .399 |
| 1911 | 8,920 | 57.1 | 2.40 | | | |
| 1912 | 9,474 | 57.7 | 2.40 | | | |
| 1913 | 7,010 | 57.1 | 2.40 | | | |
| 1914 | 420 | 56.40 | 2.70 | | | |
| 1915 | 1,806 | 56.76 | 2.36 | | | |
| 1916 | 2,190 | 57.0 | 2.30 | .54 | | |

The next series of composite assays was communicated by Prof. W. George Waring, of Webb City. The original samples were of ores from the different camps of the district except where otherwise indicated. The methods used in making these assays have been published.[1]

*Composite assays of zinc blende from the Joplin region, 1900–1916.*

[W. George Waring, analyst.]

| Year. | Number of lots in the composite. | Percentage. | | | | |
|---|---|---|---|---|---|---|
| | | Zinc. | Iron. | Lead. | Cadmium. | Copper. |
| 1900 | 3,894 | 57.30 | 3.03 | | | |
| 1901 | 5,172 | 56.00 | 3.30 | | | |
| 1901 | 2,577 | 55.30 | 3.80 | | | |
| 1901 | a ± 2,000 | 55.90 | 3.47 | | | |
| 1902 | 2,270 | 57.08 | 2.65 | 0.904 | 0.337 | 0.050 |
| 1903 | 2,145 | 57.75 | 2.32 | 1.072 | .388 | .049 |
| 1904 | a 3,800 | 58.26 | 2.23 | .701 | .304 | .049 |
| 1904 | b 2,691 | 58.46 | 1.97 | .720 | .430 | .050 |
| 1904 | 1,984 | 58.96 | 2.10 | | | |
| 1905 | 4,520 | 58.95 | 2.00 | | | |
| 1906 | 4,638 | 58.40 | 2.20 | | | |
| 1906 | 3,968 | 58.20 | 2.29 | | | |
| 1907–8 | ± 4,000 | 58.70 | 2.00 | | | |
| 1909 | | c 57.40 | 2.60 | | | |
| 1910 | 6,377 | c 57.90 | 2.60 | | | |
| 1911 | 5,653 | 58.20 | 2.35 | .856 | .450 | .034 |
| 1912 | 6,709 | 56.72 | 2.50 | 1.070 | .256 | .022 |
| 1913 | 7,364 | 56.82 | 2.81 | 1.112 | .209 | .036 |
| 1914 | 7,981 | 56.56 | 2.80 | 1.30 | .287 | .038 |
| 1915 | 9,240 | 57.19 | 2.40 | .985 | | |
| 1916 | 10,451 | 57.95 | 2.20 | .720 | .262 | .054 |

a Joplin. b Webb City. c The composite sample included some lots of silicate ores.

[1] Waring, W. G., The volumetric determination of zinc: Am. Chem. Soc. Jour., vol. 26, No. 1, January, 1904. In addition to the composite assays for 1902 and 1903, shown in the table, the article gives the lead, copper, and cadmium content of a number of ores from individual mines in Missouri, Kentucky, and Illinois.

The complete analysis of the composite sample of the 3,800 lots of concentrate from the Joplin region in 1904, sampled by C. V. Millar and analyzed by Waring, is as follows:

*Analysis of composite sample of zinc blende from the Joplin region.*

| | | | |
|---|---|---|---|
| Zinc | 58.26 | Calcium carbonate | 1.88 |
| Cadmium | .304 | Magnesium carbonate | .85 |
| Lead | .70 | Barium sulphate | .82 |
| Iron | 2.23 | Silica | 3.95 |
| Manganese | .01 | | |
| Copper | .049 | | 99.773 |
| Sulphur | 30.72 | | |

*Analysis of a representative sample of sphalerite jig concentrates from "sheet-ground ore" from the Cartersville, Mo., area.*

[Waring & Williams Laboratories, Webb City, Mo., analyst.]

| | | | |
|---|---|---|---|
| Zinc | 59.20 | Germanium, gallium, and indium (spectroscopic determination) | Traces. |
| Cadmium | .058 | Calcium carbonate | Traces. |
| Lead | .293 | Silica (possibly including traces of barium sulphate) | 6.971 |
| Iron | 1.900 | | |
| Copper | .054 | | 99.777 |
| Sulphur | 31.301 | | |
| Manganese | | | |
| Nickel and cobalt | Traces. | | |

The year 1916, although the quantity and value of lead and zinc concentrates increased considerably, was, so far as southwestern Missouri mines were concerned, not free from discouragement. On the whole mining profits were satisfactory, though it is probable that many operators did not derive as great a net revenue in 1916 as in 1915. Operating costs were high, a storm in June flooded many of the producing mines, and lack of an adequate water supply reduced the output in the latter part of the year. Prices for coal advanced 50 per cent and deliveries were uncertain. Electric power supply was curtailed, first by low water at the White River plant of the Empire District Electric Co., and then by the overloading of the steam-driven turbines at Riverton, which resulted in breakdowns at that plant. Everything possible was done by the Empire District Electric Co. to relieve the situation, but mines which were operating on double shifts were restricted to one 10-hour shift a day and then irregular shift hours were dictated so as to remove the peak of the load. Development was active in the "sheet ground" areas, especially before the period of low prices offered for concentrates in July, August, and September. A considerable part of the development and mill building was done by well-known operators in "sheet ground." Some large transfers of mining property were made, of which the most important was the transfer of the Joplin, Oronogo, Granby, and Spurgeon lands of the Granby Mining & Smelting Co. to the American Lead, Zinc & Smelting Co. The concentrating plants erected were usually of large capacity and of excellent equipment. All mining machinery and supplies were scarce and expensive and the cost of building plants was much more than in 1914 and 1915. Experimental flotation plants were used to treat slimes at several mines with satisfactory results, but the quantity of concentrates recovered at such plants was negligible.

Development of mines in "soft ground" was not more extensive than normal in the older camps, and the increased output from "soft

ground" mining was due to more extended development of properties in outlying districts. The mines in Barry, Greene, Dade, Christian and Ozark counties yielded an aggregate output much larger than it has been for many years. Some new mills were built in these counties but generally the output was that of many small mines. As the total increase in the production of sphalerite concentrates from "soft ground" mines in southwestern Missouri in 1916 was only 2,328 tons and that of zinc silicate and carbonate about 1,500 tons, it is evident that the development and working of "soft ground" properties near Joplin and other old camps were only sufficient to take the place of worked-out and abandoned mines.

Labor was scarce at certain times, but as mine wages in the Joplin region are based on the price paid for concentrates there were no labor difficulties of any importance. The Missouri Legislature imposed a tax of 4 cents a ton on sphalerite and on galena concentrates and of half a cent a ton on zinc silicate to meet the cost of mine inspection. The reported sales of galena and lead carbonate concentrates from southwestern Missouri were about 6,400 tone more than in 1915. The sales of zinc carbonate and silicate increased 1,500 tons and those of sphalerite 35,700 tons. The stocks of zinc concentrates at the beginning of 1916 were approximately 5,600 tons. The low prices paid during the summer months resulted in the accumulation of more than 30,000 tons of ore in bins in the Joplin region. Part of this surplus ore, however, was held at mines in Oklahoma and Kansas. The rapid advance in quoted base prices in October and November, 1916, absorbed both the current production and the surplus stocks, so that ore bins were practically empty at the end of 1916.

The price of galena concentrates was low in the beginning of 1916 and there was probably 1,500 tons in stock. Stocks accumulated to about 2,500 tons in July, but this surplus and the weekly output was sold during the last months of 1916, so that the stocks at the end of the year were less than 500 tons.

The production of southwestern Missouri was approximately 6,000 tons of sphalerite, 500 tons of zinc silicate, and 750 tons of galena in the first week in January, 1916. Most of the large plants were operated steadily except in the weeks when compelled to curtail working by reason of the shortage of electric power. As indicated by the total production for the year 1916, the average weekly output of sphalerite concentrates from mines in southwestern Missouri was about 5,400 tons.

### PRICES AND PRODUCTION.

The average quoted base prices for 60 per cent sphalerite were highest in February, when some concentrates sold for $130 a ton. The outstanding feature of the ore market was the great difference between the base prices offered at different periods during 1916. The margin between the base prices offered for the high and for the medium and low grades of concentrates was not so great in 1916 as in 1915. The demand for high-grade lead-free sphalerite was strong and a constant effort was made by operators to produce sphalerite concentrates having a lead content of less than 0.2 per cent, for the margin between high-grade concentrates and low and medium grade concentrates was seldom less than $10 a ton and was

frequently more than $10. In the first week in January the base prices quoted were from $85 to $110. Base prices for the lower grades advanced to $107, and for high grades to $125 and $130 in the last half of February. The March and April base prices fluctuated between $80 and $100 for low-grade concentrates and $100 to $125 for high grade. At the end of May the prevailing quotations ranged from $60 to $95, in June from $70 to $90, in July from $50 to $90. The August and September base prices were the lowest in 1916, when prices for low-grade concentrates ranged from $45 to $50 and for high-grade concentrates from $65 to $70. Prices then gradually increased during October, November, and the first two weeks in December, when the base prices reached $90 for low-grade concentrates and $105 for high-grade concentrates. There was a reaction the latter part of December and the year closed with low-grade concentrates quoted at $65 and high grade at $82.50.

Base prices for calamine or zinc silicate ores followed the sphalerite quotations more closely in 1916 than in 1915. The lowest base prices were in September, when they ranged from $30 to $40 a ton, and the highest were in February, when they ranged from $80 to $90 a ton.

The quoted price for 80 per cent galena showed wide variations, opening in January at $70 a ton and closing in December at $90 a ton. During the year galena sold for as much as $102 a ton in March and April and for as little as $65 in August and September. The high prices did not stimulate the lead production and nearly all of the increased output from southwestern Missouri was due to the activity in "sheet ground" districts.

The average price paid for sphalerite of blende in 1916 was $82.60, as compared with $76.25 in 1915, $38.74 in 1914, $40.70 in 1913, and $50.44 in 1912; and for zinc silicate or carbonate concentrates it was $50.21 in 1916, $45 in 1915, $21.13 in 1914, $22.45 in 1913, and $28.95 in 1912. The average price paid for galena concentrates was $84.29 in 1916, as compared with $52.52 in 1915, $46.83 in 1914, $51.50 in 1913, $55.36 in 1912, and $55.75 in 1911. These prices are not average base price quotations but are the actual average prices calculated from the quantity sold and the values reported to the United States Geological Survey by the sellers.

The prices received by the producers show that the average actual selling price of sphalerite in 1916 was $6.35 a ton more than in 1915, an increase of 8 per cent, and that the corresponding increase in prices for zinc carbonate and silicate in 1916 was $5.21, a larger percentage of increase than in the price of sphalerite.

On the other hand the increased cost of producing a ton of sphalerite concentrates certainly advanced more than 8 per cent during 1916, so that the profit from many properties must have been less than in 1915.

The average metal content of sphalerite concentrates derived from "soft ground" increased from 57.7 per cent in 1915 to 58.1 per cent in 1916, and the content of those derived from "sheet ground" increased from 59.1 in 1915 to 59.2 per cent in 1916. The average metal content of the galena concentrates derived from "soft ground" was 1.2 per cent less in 1916 than in 1915.

The average metal content of the galena derived from "sheet ground" remained about as low as in 1915. This was at least partly

owing to the fact that sphalerite concentrates containing little or no lead were in special demand and brought much higher base prices, so that it was profitable to favor the recovery of zinc concentrates at the expense of the galena.

The recovery of sphalerite and galena concentrates from "sheet ground" was approximately the same for the years 1910, 1911, 1912, 1913, and 1914, indicating clearly that about 2.6 per cent of concentrates is what may be expected as the approximate recovery for a term of years from this class of deposits when sphalerite concentrates prices ranged from $45 to $50 a ton. In 1915 and 1916 miners of "sheet ground" took advantage of the unusual conditions to treat increased quantities of thin "dirt," as shown by the average recovery in 1915 and 1916 of concentrates from this character of ground, which declined from 2.67 per cent in 1914 to 2.19 per cent in 1916.

The price of fuel, powder, iron, and other mine supplies in 1916 increased so much that "sheet ground" mining, where the average recovery in concentrates was about 2 per cent, was not very profitable when sphalerite concentrates sold for $70 to $75 a ton. The large advance in the price paid for galena during the last part of 1916, however, materially aided the "sheet ground" operators.

The average recovery of concentrates from "soft ground" decreased from 3.88 per cent in 1915 to 3.38 per cent in 1916. The decrease in the average recovery of lead concentrates fron the "dirt" treated was especially notable, as it was 0.20 per cent less than in 1914. There were less "soft ground" mines producing large yields of "cog" or free lead in 1915 and 1916.

The total ore or "dirt" treated increased from 10,505,000 tons in 1915 to 13,196,400 tons in 1916. The "dirt" treated from "sheet ground" was 8,484,700 tons, an increase of about 1,979,000 tons, and that from "soft ground" was 4,711,700 tons, an increase of about 707,000 tons. This shows that the output of ore or "dirt" from the operations in "sheet ground" increased about 30 per cent and that from the "soft ground" about 18 per cent.

In 1916 the sphalerite concentrates derived from "sheet ground" mines amounted to 157,804 tons, and the galena concentrates to 28,077 tons. In 1916 "soft ground" mines yielded 119,372 tons of sphalerite, 13,263 tons of galena, and all of the lead carbonate, zinc silicate, and zinc carbonate concentrates. The production of sphalerite concentrates from "sheet ground" increased 33,737 tons, and that of galena 6,419 tons. The increase of sphalerite from "soft ground" was only 2,371 tons and that of galena only 673 tons. It must not be assumed that the small increase from "soft ground" was due to lack of prospecting or active working, for the number of small mines, especially in outside districts, showed a large increase. It was because very few of the new mines were large producers and because of the comparatively small output from hundreds of small mines.

The total value of all concentrates derived from "sheet ground" mines was $15,978,488 and from "soft ground" mines $11,643,807. This shows that the value of the production of concentrates from "soft ground" in 1916 amounted to $4,334,681 less than the production from "sheet ground," whereas it was only $525,290 less in value in 1915.

The Webb City-Carterville-Prosperity district, which includes many of the "sheet ground" mines, was again much the largest producer of both blende and galena concentrates in southwestern Missouri. It produced 55 per cent of the galena concentrates and 41 per cent of the sphalerite sold in 1915.

The quantity of crude ore or "dirt" raised is a better indication of the extent of mining activity than the production of concentrates, for the "sheet ground" ore is of lower average tenor than the "soft ground" ore. The leading position of the district is more adequately shown by the fact that the estimated quantity of ore mined in the Webb City-Carterville-Prosperity district in 1916 was about 6,105,400 tons, or nearly 47 per cent of the total crude ore raised in southwestern Missouri, and that the output in 1916 was about 1,120,000 tons more than in 1915.

Though the production from the Joplin district did not increase in the same proportion as the output from the Duenweg-Porto Rico district, it remained the second most productive district. Duenweg-Porto Rico district had a largely increased production in 1916 and its output was three times as large as that of the Granby district. There were small decreases in the output from the Alba-Neck City and Oronogo districts, but the value of the concentrates showed considerable increases. The other districts that showed an increased yield of zinc concentrates were Ash Grove-Everton, Springfield, Aurora, Carthage, Cave Springs, McDowell, Sarcoxie, Spurgeon, Stott City, Wentworth, Zincite-Klondike, and the various camps in Christian and Ozark counties; and there was a decreased production in the Carl Junction, Sherwood-Thoms Station, and Spring City-Beef Branch districts. About 90 per cent of the galena concentrates from southwestern Missouri were produced in the Webb City, Joplin, Duenweg, and Oronogo districts; and 36 per cent of the zinc silicate and carbonate was derived from mines in the Granby district.

Many of the details of mine development, descriptions of the older concentration plants, and other data have been given in previous reports, which can be had upon request. The more important developments during 1916 are described under the various district reviews.

## REVIEW BY DISTRICTS.

*Alba-Neck City district.*—The shipments of sphalerite from this district in 1916 decreased about 1,450 tons, those of lead ore increased 17 tons, and those of zinc silicate decreased 23 tons. The total value of all concentrates sold was $1,161,463, or $9,679 more than the value in 1915 when prices were lower. The decreased output was entirely due to a smaller output from the Quick Seven and Little Mary mines northwest of Neck City.

Mines on Reliance land produced two-thirds of the galena shipped in 1916 and the largest aggregate output of zinc concentrates, but the Utah-Missouri Mines Co. had the largest individual yield of sphalerite concentrates. The productive leases on the Reliance land in 1916 were the Cuckleburr Mining Co., R. A. M. Mining Co., Jessie Milling Co., Galena Boosters Mining Co., Lucky Seven Mining Co., and Last Chance Mining Co., of which the first four are equipped with concentrating plants. A large part of the output from the leases of the Davidson-Joplin Mines Co. was that of the Sunflower

Zinc Co., which used a 150-ton mill to treat dirt mined at a depth of about 190 feet. Other producers on the property were the Herman Mining Co. and Playter Bros., who operated the old Water Oak mill on the Aylor tract. The Utah-Missouri Mines Co. operated the Black Hawk mine and 200-ton mill on Calumet Zinc Co. land until June, 1916, when work was suspended. The Goldfield mine on Federal land was worked by the same company and a new shaft was sunk and a large concentrating plant built. Most of the production of the Utah-Missouri Mines Co., however, was from the Lucky Tiger mine on Penn Zinc Co. land. The shaft at the Lucky Tiger mine was sunk to the 276-foot level and ore from this shaft and from the Big 4 shaft was milled at a 250-ton concentrating plant. The old workings of the rich Century mine on the Longacre & Chapman land were abandoned and the mill removed after a large output of high-grade sphalerite had been recovered by the Tiajuana Mining Co. A considerable quantity of concentrates was shipped from the Toledo-Joplin mine on the Lanyon land prior to the litigation which caused the closing of the property.

One of the largest producers in the vicinity of Alba was the Joplin Concentrating Co. on the Fox land. All tailings were treated at the 150-ton mill and preparations were made to reopen the old Dew Drop mine. The Stewart land, leased to the Saxet Mining Co., was subleased to a number of small operators and the production of sphalerite, zinc silicate, and galena was obtained from dirt mined by means of seven shallow shafts and recovered by hand jigging.

On the Haworth land F. M. Sponable did development work, but the 200-ton concentrating plant was not completed until 1917.

The Cliffwood, the most northwesterly mine in the district, was under lease to the Purcell Mining Co., which shipped a large quantity of high-grade sphalerite. The ore treated was obtained through two shafts 165 feet in depth, and two concentrating plants were operated.

The Little Mary mine on the Weaver land, adjoining the Quick Seven, was under lease to the Trigger Mining Co. The mine is on the banks of Spring River and the workings finally became so dangerous that the mine was abandoned and the mill was removed.

The production from the Richardson land lying northwest of Neck City was considerably less in 1916 than in 1915. In September the Missouri Zinc Mines Co. purchased the Quick Seven and Tessie M. leases, and the new owners decided that it was best to abandon the hoisting of ore through shafts and operate the property entirely by open cut, as the drifts at the old Quick Seven mine were becoming too dangerous to continue mining the ore from the 100-foot pit and drawing it underground to the mill shaft. The overburden is now removed by stripping with a drag-line excavator equipped with buckets holding a ton and the ore is now sent directly from the open pit to the mill. New 110-horsepower Bessemer gas engines and other equipment were added to the Quick Seven mill, and the old Texmo mill will also be rebuilt and used. The improvements and equipment necessary for the new method of working this property were expensive, but the costs of mining have been materially lowered and the mine workings made safe. It has long been recognized that the open-cut method was the most efficient way to operate this property, as the ground was very soft and required heavy timbering. Moreover, the ore body extended to within 25 feet of the

surface and the workings were always liable to be broken into by the waters from Spring River.

*Ash Grove-Everton district.*—The mining in this vicinity is all shallow, none of the workings exceeding 80 feet in depth. The ore, until 1916, was all raised by means of horse whims and cleaned on hand jigs. Most of the lead and the zinc silicate from the Ash Grove section was mined on the Duncan land in Boone Township by the Ash Grove Mining Co., which constructed and operated a 100-ton concentrating plant in 1916. The Davis Mining & Milling Co. was sinking a shaft on the Davis land and will probably erect a 100-ton mill. Lessees on the King, Roundtree, and Morrison lands shipped a considerable quantity of zinc silicate and a small quantity of galena. The zinc carbonate and silicate produced in the Everton camp was the output of small lessees near Corry and Dadeville and was purchased and shipped by Harrison & Hall, of Greenfield, Mo Among the productive lands were those of A. W. Brown, Landers & Pyle, L. C. Duneway, Edwin Frieze, and George T. Hulston.

The high prices paid for zinc silicate resulted in many small shafts being sunk and in the rapid increase in the number of mines, until at the end of the year the output of silicate was larger than in most of the southwestern districts and four times as large as it was in 1915.

The Ash Grove Mining Co. did the deepest mining in the districts. Two shafts were used to obtain ore from levels between 75 and 80 feet.

*Aurora district.*—The production of lead concentrates of this district in 1916 was about 200 tons less than in 1915. The output of zinc silicate and carbonate increased 902 tons and that of sphalerite increased 2,302 tons. A part of the output was made by lessees working shallow ground, the crude ore or "dirt" being treated at custom mills or sold in the rough. This output, though as large as in preceding years, was not of such relative importance in 1916, for the production of sphalerite concentrates increased nearly 400 per cent and there was a decided revival in the working of ground at lower levels. The lessees of the United Zinc Co. produced the largest quantity of zinc silicate in addition to some galena and sphalerite nearly all of which was obtained from levels above 40 feet and was sold to chatting plants. The Scottish Mining Co. opened the deep ground at the old No. 1 mine and built a 150-ton plant, which was leased later in 1916 to the Missouri Hydraulic Mining Co. A new 100-ton mill was erected on the Stratton lease which was not completed until January, 1917. The Missouri Hydraulic Co. also has a mill on the Jones and Federal lands. The old 150-ton mill of the No. 4 Drill Co. on the C. W. Tooker land was removed and rebuilt on the Campbell & Schmook land. A good output of sphalerite was made from ore mined at 230 feet before the mill was removed. The small mill owned by the Goat Mining & Development Co. on the Stewart land was steadily operated and a good recovery of zinc silicate was made.

A considerable portion of the zinc silicate from the Aurora district, in addition to a small quantity of sphalerite and galena concentrates, was, as in former years, shipped by C. C. Plank, who controls or manages the Cleveland Aurora Mineral Land Co., Midland Mining Co., Milton Mining Co., and Aurora Sludge Mill Co.

The producers on the Duckworth land were Johnson & Co., Thos. Murphy, and Edinger & Co.; those on the McCormick land were Apple, Dillard & Co., and W. E. Stair; and those on the Kentucky Mining Co. land were Marks & Co., Ward & Co., McCullough & Co., Allman & Co., and Marshall & Co. There were a number of small producers on the Decatur Lead & Zinc Co.'s land and the Sphalerite Mining Co.'s land, leased to E. K. Johnson, and also on the Sedalia land, Campbell-Schmook land, and the Wyoming lease of the Grier land.

Four shafts were in operation at the old Louisville mine, which is equipped with a 75-ton mill and made a good output of zinc silicate.

The 100-ton mill at the Daisy Bell mine on the Sphalerite land was run exclusively as a custom and chatting plant, as was the 100-ton mill of the Sandridge Mining Co. on the Bushman land.

The most prominent of the new operators mining and prospecting the ore bodies below 100 feet was the Red Wasp Mining Co. on the Flournoy land, which produced more than 50 per cent of the sphalerite concentrates shipped from the Aurora district in 1916. The 150-ton concentrating plant was ready for operation in January and ran steadily all the year.

The Fleming & McNatt land was drilled by the Arrow Mining Co. and a shaft was started, though the construction of the milling plant was not commenced until February, 1917. The Coleman land was thoroughly drilled by the Aurora Union Mining Co. with such satisfactory results that a shaft was sunk and a 300-ton mill erected. The mill was not completed until December so that the production of sphalerite was not large.

Another new operator was the Scott, Phelps & Scott Mining Co., which discovered an ore body lying at a depth of 260 feet on the Scott land. The shaft had been sunk to a depth of 180 feet by the end of 1916.

*Carl Junction district.*—There were fewer operating companies in this district in 1916 than in any other of the old districts in the Joplin region. The lower workings of former large producers were flooded and most of the concentrating plants were removed. The production of sphalerite was 50 per cent less than the relatively small output in 1915 and the outlook for any increase in 1917 is unfavorable. Most of the production in 1916 was that of the Lucky Shot Mining Co. on the Anderson land considerably north of the old field. A good output of high-grade lead-free sphalerite was recovered at the 75-ton mill. The only other active mine in the district was that of the Dallas Mining Co. on the Knight land, which made some production early in 1916.

*Carthage district.*—The reports received from the Carthage district showed that the production in 1916 was the largest made for many years. The production of galena concentrates increased 62 tons and the shipments of sphalerite increased from 1,153 tons in 1915 to 3,835 tons in 1916. More development work was done than for many years, but the increased output in 1916 was mainly due to the steady operation of the Hermosa mine and mill of the Coahuila Lead & Zinc Co. The sphalerite concentrates shipped from this mine had an average zinc content of 61 per cent and the dirt milled yielded about 4.2 per cent in concentrates.

The Princeton mine on Magnet Mining Co. land was sold to the Bee Tree Mining Co. and had a fair output of high-grade sphalerite.

The old Vesuvius mine on the Dewey land was unwatered and a sludge plant was added to the 200-ton mill by the Vesuvius Mining Co. (Inc.). A new shaft was sunk below the old workings abandoned some years ago. Drifts were then run under the caved ground and the "dirt" pulled to the lower level. Some old tailings were also milled and the concentrates recovered from both sources formed a substantial part of the production of the district.

The small quantity of zinc silicate shipped in 1916 was from an old dump on the Mansur land.

Development work only was done by the Scammon Mining Co., on the Aylor land, the G. M. Mining Co. on the Glenn land, the Chatauqua Mining Co. on the Church of God land, the Cliffwood Mining Co. on the Owens land, and the Osage Mining Co. on Magnet land. The G. M. Mining Co. already has a concentrating plant on its property, and new plants will be built by the Scammon Mining Co. and the Osage Mining Co.

*Cave Springs district.*—The production of lead and zinc from the Cave Springs district was slightly more in 1916 than in 1915, though there was no large new producing mine opened. The McClintock Mining Co. developed a new mine on the Ferguson land lying on the State line between Kansas and Missouri and also erected a 150-ton concentrating plant. Several hundred tons of high-grade sphalerite were shipped, but apparently operations were not profitable for the mine was closed and the mill removed. The Hartford No. 2 mine on the Kansas-Missouri Land & Mining Co.'s property was the largest producer in the district, although its output was less than usual because the mine was flooded and the surface equipment damaged by the storm in June. The Cave Springs Lead & Zinc Co.'s mine on the Carter land had a considerable production of lead and zinc prior to July, 1916. The 300-ton mill was then sold to the Golden Rod Mining Co. and removed to the Miami district. Mining of the ore body at the 240-foot level was suspended and the ore at the 60-foot and 150-foot levels was mined by sublessees and the dirt was sent to custom mills. There was a considerable quantity of lead and zinc concentrates shipped from the Schemerhorn land by sublessees of the White Oak Mining Co. Four shafts from 90 to 140 feet in depth were used and all the ore mined was custom milled. The production from the Hartley land was less than in 1915, and the McCullough & Murdock lease was transferred to the Mustain Mining Co., which drilled the land, sunk a new shaft, and will probably erect a concentrating plant.

The 240-acre tract of the Walnut Hollow Land Co., northwest of Cave Springs, was drilled both by the owners and by the Century Zinc Co. It is stated that good ore was located at various levels. Two shafts were started and the old Arkansas mill has been moved from Prosperity to the property and will be operated by the land owners.

*Duenweg-Porto Rico district.*—This district is one which contains the second largest number of "sheet ground" mines in the Joplin region, and it was one of the most active in 1916. The district production of sphalerite increased from 27,789 tons in 1915 to 40,709 tons in 1916, and that of zinc silicate decreased from 1,507 tons in 1915 to 1,302 tons in 1916. The output of galena concentrates

increased from 3,120 tons to 6,538 tons. The total value received in 1916 for lead and zinc concentrates sold was $3,961,324, against $2,526,310 in 1915. The whole increase in yield of sphalerite was due to the mining of "sheet ground," for the output from mines of this character increased from 2,082 tons of galena and 22,352 tons of sphalerite in 1915 to 4,459 tons of galena and 34,496 tons of sphalerite in 1916. The "sheet ground" mines produced 68 per cent of the galena and nearly 85 per cent of the sphalerite concentrates, which was a larger proportion than in 1915.

The Coahuila Lead & Zinc Co. was again the largest producer in the district, though its output was not much more than that of the Athletic Mining Co. and the Onamena Mining Co. The output from the American Beauty mine, of the St. Regis Mining Co., and of the Vogey mine, of the American Zinc, Lead & Smelting Co., also compared favorably with the yield from the Coahuila. The combined output from the five above-named properties was equal to 40 per cent of the galena concentrates and 60 per cent of the sphalerite concentrates shipped from the Duenweg district in 1916. A new concentrating plant having a capacity of 1,200 tons in 24 hours was erected at the Coahuila mine, so that 2,100 tons of dirt can be treated daily. The capacity of the Lincoln mill of the Athletic Mining Co. was increased by the addition of two jigs to 1,000 tons daily. A new steam power plant, concrete settling tank, and an electric skip hoist were added to the equipment. The old San Gabriel shaft on the adjoining Wolfheart lease was reopened.

The first lease on the Boston Duenweg land was acquired by the Onamena Mining Co., and the old Wilson mine and mill, which is now known as Onamena No. 2, was equipped with 10 new tables. The Baltic mine on the Onamena lease was taken over by W. B. Shackelford and associates and had a larger output than Onamena No. 2. The Onamena Mining Co. also operated a 350-ton mill on the Chase land and a 200-ton mill on the Hill land.

The production of galena in the ore at the Fidelity Mining Co. lease was proportionately greater than at any other large mine in the district. A Corliss engine and new boilers were added to the mill equipment. The Franklin mine on the Cosgrove land was purchased by the O. F. & L. Mining Co., the former owners of the Baltic mine. The Barnett Mining Co. leased the Chappel mill on Trinity land and the old mine produced a good output of sphalerite from "sheet ground" ore. "Sheet ground" was mined at the Marjorie Stewart and Porto Rico mines on the Raymond land, and "soft ground" at the National, Charter Oak, and other leases. The Porto Rico mine, which is equipped with a 175-ton mill, was sold to the Lincoln Zinc Smelting Corporation.

A small quantity of concentrates was recovered from "sheet ground" by the Gotham Mining Co. on the Tetrault land and from the old Overland mine on the Stevison Rogers Mining Co.'s land before the mills were shut down. The Scott Mining Co., operated two shafts on the Ground & Irwin land and milled dirt taken from an average depth of 216 feet at a 300-ton plant. It is stated that drilling showed "sheet ground" ore having a zinc content of about 8 per cent at levels between 231 and 273 feet.

The production from the Barratt land was small in 1916, but a shaft was sunk and a 350-ton mill built by the A. R. G. Mining Co.

and the Hartford Mining Co. cleaned out two old shafts and built a 500-ton concentrating plant. "Sheet ground" is mined by both lessees.

The most productive leaseholds on which "soft ground" was mined in 1916 were those on the Chew land, and of these the What Cheer mine had the largest output. The Douglas & Anderson lease was worked by several lessees and the new 200-ton mill on the ground was used to treat tailings. The Owosso Development Co. mined ore at 242 feet and then sunk the mill shaft to a depth of 262 feet. A new shaft was also sunk and the capacity of the concentrating plant increased. The development work done is expected to increase the production largely in 1917. The only other large mine on the Chew land was the Melrose, owned by Hugh Correll. The productive leases on the Crown Crest land were the Crown Point Mining Co. and its successor the Bizzy Izzy Mining Co., the Yellow Jacket Mining Co., and the Muskogee Mining Co. Two 150-ton mills were used to concentrate ore mined at a depth of about 130 feet.

Galena concentrates were produced mainly at the Fletcher Clear lease on the Freeman land, the One Spot mine on the Bennett land, the Amos Freeman lease of the Frerer land, and the Farlow lease of the Walker land. The yield of hand cobbed galena from the mine on the Frerer land was the largest obtained from any mine in the Joplin region producing no zinc ores.

The Burch Mining Co. erected a 200-ton mill and sunk three 150-foot shafts. The mill and surface equipment is one of the largest used in Missouri for the mining and milling of zinc silicate. The production of zinc silicate from the Home Talent lease of the Hall land was large in the first part of 1916, but operations were virtually suspended in the fall of 1916.

One of the best of the new properties opened in 1916 was that of the Evans Hall Soy Mining Co. on the Orr land. A 250-ton concentrating plant was erected after ore in "soft ground" had been found at levels between 120 and 190 feet and ore in "sheet ground" between 200 and 225 feet. The dirt milled yielded about 4 per cent in concentrates and a good output was made during the short time the plant was in operation.

Another new mine which had a comparatively small output of sphalerite in 1916 but which will probably have a large yield in 1917 was that of the E. & N. Mining Co. on the Saddtler land. A 100-ton mill was erected, which was run on ore taken from "soft ground" at the 114-foot level.

Considerable drifting was done and three shafts were sunk by the C. M. H. Mining Co. on the Malloy lease south of the Boston-Duenweg land. The heavy flow of water delayed work on this lease and on that of the Bell Mining Co. on adjoining land.

Other lands and leases which produced lead or zinc concentrates in 1916 or upon which development was done were as follows: Acme Lead & Zinc Co. and Rusk Sludge Co. on the December tract, Davidson Lead & Zinc Co. on the Corl land, Cornell & Co. on the Knight land, Ten Per Cent Prospecting Co. on the Mussellman land, Ellis & Co. on the J. K. Wingert land, various lessees on the Henry Weyman land, and Playter Bros. on the Carter land.

*Diamond District.*—Considerable prospecting, drilling and development work was done in the Diamond district in 1916, and lead and

zinc concentrates valued at about $36,000 were shipped. The Soon Over Mining Co., on the Weymann land, was the largest shipper of zinc silicate, which was mined at a depth of about 75 feet. Lessees on the Gregg land shipped both galena and sphalerite, but most of the sphalerite sold was that of the Neosho & Granby Mining Co. on the Jones land. This company sunk a 112-foot shaft and erected a 150-ton concentrating plant. The Wade Mining Co. also built a 150-ton mill in 1916 but no concentrates were sold.

*Fairview and Pioneer districts.*—These districts in Barry County produced in 1916 a small quantity of sphalerite and zinc silicate which was mined from shallow shafts and tunnels. All the concentrates were hand cobbed or recovered by means of hand jigs. Among the producing properties were the Pioneer Milling Co. on the Wagner land, J. M. Brewer on the Van Hook land, Birkes & Williams on the Northcutt land, and L. D. Freeman and James McNeill on the Velton land.

*Granby district.*—The output of sphalerite concentrates in this district in 1916 was 6,924 tons, that of zinc silicate 9,310 tons, and that of lead concentrates 308 tons. About 40 per cent of the output of zinc carbonate and silicate concentrates from the Joplin region came from the Granby district. Most of the producing territory is now controlled by the American Lead, Zinc & Smelting Co., which took over the smelter, mines, and all the lands owned by the Granby Mining & Smelting Co., a considerable part of which has never been mined. The land at Granby, however, has had a large production of lead and zinc for many years, and other tracts near Oronogo, Joplin, and Spurgeon, in Missouri, and near Cave Creek, in Arkansas, have been and are now extensively mined. It is probable that the present owners of the old Granby land will operate several mines at Granby and not confine the company mining to the Klondike mine. Much of the mining by small companies and by individuals is in shallow workings that yield galena and zinc silicate ore. The larger producing lessees on the Granby lands were the Broken Hill Co., Margaret D. Mining Co., Golden Rule Mining Co., Buick Mining Co., Little Boss Mining Co., Katy Mining & Milling Co., Brewer & Co., J. R. Underwood Mining Co., Post Oak Mining Co., Four Flush Mining Co., Granby Sludge Co., Fighting Negro Mining Co., Water Dog Mining Co., Hash Richardson & Co., Fortune Teller Mining Co., Local Mining Co., Free Silver Mining Co., Trilby Mining Co., E. T. Perkins, O. L. Goade, Greenhorn Mining Co., Free Trade Mining Co., Courtney & Co., and Waterworks Mining Co. The depth of mining varied from very shallow openings to 215 feet, and 12 concentrating plants having a total capacity of 2,300 tons were operated.

The zinc silicate ores were mined chiefly at depths from 40 to 100 feet and sphalerite ore at depths of 100 to 215 feet.

The 200-ton custom concentrating plant of the Granby Mining & Smelting Co. is so equipped that it can be used to concentrate either blende or calamine ore. Many of the lessees on this land have no concentrating equipment and a large quantity of ore is treated at custom mills or sold in the rough, so that almost one-third of the blende and silicate concentrates shipped were recovered at the Granby custom plant.

The Granby Mining & Smelting Co. continued the development of the ore body located at the 180-foot level of the Klondike mine.

Two shafts were in ore and drifts were driven to connect them. The ore faces are 30 to 40 feet high and the dirt milled yielded between 4 and 5 per cent in concentrates. The concentrating plant of 1,000 tons daily capacity is driven by electric power and the adjoining sludge plant is large and well equipped. Insufficient electric power hampered operations for several months and the production was less than was normally expected.

The J. R. Underwood Mining Co. was one of the largest producers in the Granby district. Part of the output was derived from the Davis land but most of the ore was mined on the adjoining lease on Granby land. The output of silicate from the land of the St. Paul Mining Co. was small though considerable drilling was done.

The Matt Zogg land in sec. 20, T. 25 N., R. 30 W., was actively prospected in 1916. Two shifts were completed and five others were being sunk. A 150-ton concentrating plant erected by R. L. McGee was not completed until January, 1917.

The production from leases on the Thomas Douglas land in sec. 31, T. 26 N., R. 25 W., is included with that of Granby district. A 100-ton mill was built by the M. & R. Mining Co. and two 125-foot shafts were sunk. The output of high-grade zinc silicate was large and the average recovery of concentrates from the ore treated was more than 10 per cent. The old Silver Plume mine on the Chase land, 3 miles southwest of Granby, has been leased to the M. K. & T. Mining Co., which is erecting a 500-ton mill. The lessee will mine "sheet ground" at the 205-foot level.

*Joplin district.*—There was a considerable increase in the value of the lead and zinc concentrates from the Joplin district in 1916, but there was no increase in the quantity shipped. For the first time the output of the Joplin district was less than that of the Miami district in Oklahoma. The Joplin district was very active during the early part of the year; much development was done; and there were numerous transfers of mines and mining lands. After the period of low prices in July and August less attention was given to the Joplin district by investors who were prepared to operate on a large scale. On the whole development was about normal and the output of new mines equalled that of the mines abandoned or worked out. The scarcity of water for milling caused some of the large mines in the west Joplin camp to remain idle for several months and the inability to obtain electric power for steady operation or for running double shift reduced the output of concentrates the last six months of 1916. There was no apparent decrease in the number of mines operated, though many of them had a small output. The unusual flow of capital seeking investment in the Miami district will undoubtedly result in a decrease in capital invested in large plants in the vicinity of Joplin, but the "soft ground" and the small capital required to put prospects on a paying basis will continue to make the Joplin district attractive to investors who can not afford to develop mines in the Miami district.

The mines near Thoms Station and other camps are locally classed as belonging to the Joplin district and their output is included with that of Joplin, and in considering the relative output of Joplin camp (as given in the table of production), compared with that of the eastern and the extreme western districts of the Joplin region, the output of these camps must be taken into consideration.

The district retained its place as the second largest producer in southwestern Missouri, though the percentage of increase in production was much larger in the Duenweg district than it was in the Joplin district. The sales of concentrates in 1916 were as follows: Galena, 5,949 tons, valued at $492,383; lead carbonate, 2 tons, valued at $97; zinc blende, 51,259 tons, valued at $4,279,912; zinc carbonate and silicate, 3,339 tons, valued at $154,907. As compared with 1915 the sales in 1916 of lead concentrates decreased 1,254 tons, these of zinc silicate and carbonate 121 tons, and those of zinc blende increased 2,185 tons, and the total value of all concentrates sold increased $626,113, or 15 per cent. About 56 per cent of the zinc blende and 40 per cent of the galena concentrates were recovered from ore mined in "soft ground." This is 4 per cent less of the zinc concentrates and 26 per cent less of the galena concentrates than the corresponding recoveries in 1915 from "soft ground." This decrease reflected the importance of the output of the "sheet ground" in the west Joplin camp. The production from "sheet ground" increased from 2,070 tons of galena and 19,782 tons of sphalerite in 1915 to 3,671 tons of galena and 24,311 tons of sphalerite in 1916.

One of the largest producers from "sheet ground" was the A. W. C. Mining Co., notwithstanding that the mills owned by it were shut down for several months owing to the scarcity of water and electric power. Mine and mill No. 2 of this company is located on a lease of the Banner Investment Co.'s land. Mills Nos. 1, 3, and 4 are located on land purchased from Luke & Ash in 1916. A new 190-foot shaft was sunk and No. 4 mill, which has a capacity of 300 tons, was erected in 1916. The Poland Tailing Co. milled old tailings from the Hero mine on the Banner land, and the Spencer Sludge Co. recovered a small quantity of blende concentrates from the A. W. C. fee. The Geronimo and Priscilla mines of the Underwriters Land Co. on the Connor land were abandoned and the concentrating plant was removed. A large output of sphalerite concentrates and a considerable quantity of galena was shipped by the Liberty Bell Mining Co. and the Consumers Mining Co., both located on land of the Expansion Mining Co. A Dorr thickener, sand jigs, and other equipment were added to the S. Y. Ramage Mining Co.'s mill on the Deering land and the capacity of the mill was increased to 500 tons. The Metzler land produced a large output of both lead and zinc concentrates from "sheet ground" and "soft ground." Two mills were operated on the land; that of the Gibson Mining Co., of 300 tons capacity, treated ore from "sheet ground" mined at 182 feet, and that of the Once More Mining Co., of 200 tons capacity, treated ore from "soft ground." The production from the Lambert land was about the same as in 1915. A large part of the production in 1916 was that of O. R. Symmes, who mined "sheet ground"; the output was milled at a 250-ton plant, which was sold to Mattes Bros. late in 1916. The production of the Dick Turpin Mining Co.'s lease was considerably reduced by delays occasioned by lack of power. The ground was opened by two shafts and "sheet ground" was mined. The Osceola mill No. 3, on the same land, was used to treat tailings. There are two shafts, each 200 feet deep, on the Osceola lease, but the new milling plant was not erected. Considerable drilling was done on the Lambert land by the Dave Sayers Mining Co. and by Charles L. Turner. The Falls City

mine on the Higgins land was sold to the Rebecca Mining Co. and the old Martha Ball mine on the same land was purchased by the Lindsay Lead & Zinc Co. "Sheet ground" was mined at both properties and both milling plants were operated part of the year. The sphalerite concentrates from the mines on this land had a zinc content between 61 and 62 per cent.

The old Samson mine was purchased by the Airdale Mining Co. and the 300-ton mill was rebuilt in March, 1916. "Sheet ground" at the 200-foot level was mined by means of three shafts. The most southwesterly "sheet ground" mine in the district is the Handford mine of the Adams-Hicks Lead & Zinc Corporation on the property of the Independent Zinc Lands Co. Part of the lease was worked by sublessees, but most of the output was from "sheet ground" mined at 117 feet. The Duquesne mill, also on the Independent land, was destroyed by fire.

One of the largest producers of both galena and sphalerite from "sheet ground" was the Sparkler Mining Co. on the Taylor & Glover land. The 300-ton electrically driven mill treated dirt hoisted through three shafts from the 180-foot level. The quantity of concentrates recovered from dirt milled was slightly less than 2.5 per cent.

The Muskingum mine, which was operated up to February, 1917, by William Kennefick, was purchased by the Coyote Mining Co. The mine is equipped with a 350-ton concentrating plant and has two shafts each 195 feet in depth. This mine made the largest production of both sphalerite and galena in the Joplin district in 1916.

The producers of galena, sphalerite, and zinc silicate concentrates from disseminated ore bodies and from shallow ground were so numerous that only brief mention can be made of a few of the largest producers, of the new mines opened, and of the lands on which new work was done or new concentrating plants or additional equipment installed. The largest output of galena was from lands of the Missouri Lead & Zinc Co., Connor Investment Co., Continental Zinc Co., American Zinc, Lead & Smelting Co., and Rex Mining & Smelting Co. Most of the zinc silicate was mined by lessees on land owned by the Campbell estate, W. L. Butts, L. B. Jones, German-American Mining Co., Home Land & Loan Co., Missouri Lead & Zinc Co., Saginaw Land & Mining Co., Rose Land & Mining Co., and Mossback Land & Mining Co. Productions of sphalerite, each amounting to more than 1,500 tons were obtained from leases on Granby, Rex, Continental, Connor Dirigo, and St. Louis Joplin lands. Properties which had a good output but less than those already named were the Grand Tower Mining Co., Oak Orchard Mining Co., Blatchley Mining & Milling Co., C. M. Foss land, lessees of J. M. Leonard, J. H. Taylor, Lone Elm Development & Mining Co. (Picher land), Empire Zinc Co., Home Land & Loan Co., Montgomery Lead & Zinc Co., United Zinc Cos., Pittsburg-Joplin Mining Co., P. L. Swartz, Douglas & Anderson, Cooper & Peters, J. B. Robb, Stokes Shoemaker Mining Co., and Scranton Mining Co.

Small shipments of lead or zinc concentrates were made by many operators, including the following: General Lead & Zinc Co., Armil Sludge Co., St. Joe Mining Co., Joplin Barber Supply Mining Co., Inter City Mining Co., and lessees of the Paoma Mining Co., Ohio Land Co., Roaring Springs Mining Co., Shoal Creek Mining Co., Ohio-

Missouri Prospecting Co., E. Thompson, Woodburn Mining Co., H. H. Gregg, C. M. Edwards, and J. W. McCullough.

Among the transfers of mining lands or leases, new mines opened, or new concentrating plants erected at mines other than in "sheet ground" were the following: At the Adirondack mine on City of Joplin land the building of a fully equipped 200-ton concentrating plant; the opening of new mines on the Connor land by Playter Bros., the McBride Mining & Milling Co., and the Squaw Mining Co. (a 150-ton mill was constructed at the McBride mine and a 50-ton mill was operated at the Squaw mine); the construction of a new 250-ton tailing mill on Continental land and of a small sludge mill and a 150-ton concentrating plant on the Blendville Mining & Leasing Co.'s lease of the Empire Zinc Co.'s land; the great activity on leases of the Missouri Lead & Zinc Co., on which 100-ton mills were erected by the Mary L. Mining Co., the Gager Mining & Milling Co., and the Culbert Lead & Zinc Co.

The old Quaker mine on the Pittsburg-Joplin land was taken over by the Coralbut Mining Co. and a new 150-ton mill was completed in March, 1916. A large output was made by taking up stope in the old workings.

The Old Friend Zinc Mining Co. erected a 150-ton mill on the Robb land and milled ore from the 85-foot level and also some old tailings. Considerable drilling was done on the St. Louis-Joplin land which has been sold to the Interstate Royalty Co., and a very large production of high-grade sphalerite concentrates was recovered at the new mill of the St. Regis Mining Co., which has a capacity of 250 tons.

*Oronogo district.*—The Oronogo district, although the output is practically from two mines, continued to have the fifth largest production of lead and zinc concentrates. The production was valued at more than $1,000,000, and the output of galena increased though that of sphalerite decreased. The Oronogo Circle and Oronogo Mutual mines were two of the largest producers in Missouri, and improvements made by them indicate greater production. The Oronogo Circle Mining Co. has completed its plans and commenced the erection of a new 1,800-ton concentrating plant, which is to be as large and as modern as any in the Joplin region. Ore in "soft ground" has been worked at the 60, 160, 220, and 290 foot levels for several years and part of the workings have had to be heavily timbered. Considerable drilling was done in 1916, and as the ore bodies in many cases extended to within 30 feet, and in some places even less than 30 feet, of the surface, it was decided that the most profitable and safe way to mine the ore was by means of an open cut and the use of a steam shovel. Some of the ore bodies contain as high as 10 per cent in lead and zinc, others as low as 2.5 per cent. Many pillars rich in ore have been left to support the roof at different levels. This ore can all be removed by steam-shovel operations when the surface waste is removed. The contemplated improvements are expensive but will result in very low costs for mining and milling, and the percentage of concentrates recovered will be larger than from most of the mines in "soft ground." The only other plant on Granby land was that of the Morning Star Milling Co.

The production of concentrates, especially of galena, at the Oronogo Mutual mine, was much larger in 1916 than in 1915. The lead production was greater than at any other mine in southwestern

Missouri. The Oronogo Mutual Mining Co. has leases on the Elliott land and numerous city lots, and also owns the fee of the 75 acres south of the mill. Three shafts were used to hoist dirt from the 180-foot level and another shaft, which is to be used solely to hoist the men and supplies, was being upraised. The mill which has a capacity of about 45 tons per hour is equipped with a sludge and table plant and a machine shop. A new power plant which will cost $70,000 was under construction. This plant will contain one 400-horsepower boiler, one 350-horsepower boiler, a Sullivan cross-compound air compressor of 2,600 cubic feet capacity, and a directly connected 1,500-kilowatt generator. A sludge plant built by Holt & Co. recovered concentrates from the slimes accumulated at old mining plants on the land purchased by the Oronogo Mutual from the American Zinc, Lead & Smelting Co.

*Reeds-Sarcoxie district.*—The production of the district in 1916 was 4,856 tons of sphalerite and 130 tons of zinc silicate, as against 2,002 tons of sphalerite and 251 tons of zinc silicate in 1915. The value of these concentrates was about $171,000 more than in 1915. Almost all the zinc silicate was produced by lessees on the H. B. Boyd land and the sphalerite was derived from the J. W. Boyd land at Sarcoxie and the Cornell land at Reeds. The Cameron mine on the Boyd land, operated by the Flannery Zinc Co., was much the largest producer in the district. Considerable underground development was done by the lessees and three new Diesel type oil engines were added to the surface plant. Ore was mined at the 300, 275, 90, and 80 foot levels and was hoisted through 4 shafts, and three new shafts were being sunk. The concentrating plant was destroyed by fire in December, but it has been rebuilt. The old Ravenswood mine was abandoned in March, 1916, by the U. S. Smelting Co., and the concentrating plant, which has a capacity of 750 tons daily, was moved to a new mine in the Miami district. The mill was in operation less than three months and the output was large, though the "dirt" was low grade.

*Thoms Station-Sherwood district.*—In 1916 this district produced 60 tons more of lead concentrates and 92 tons less of blende concentrates than in 1915 and dropped from eighth to ninth place among southwestern Missouri districts. The output of lead concentrates in 1916 was 615 tons, valued at $52,692, and that of zinc blende concentrates was 4,721 tons, valued at $310,287. There were quite a number of small mines developed in 1916 and ore was recovered by means of hand jigs at all the new mines except one on the Mexico-Joplin land. The district has been noted for its rich but small ore bodies. The large reduction of output was not due so much to the number of mines worked as to the comparatively small yield from these mines.

More than 40 per cent of the sphalerite concentrates shipped in 1916 was from the Olive-Cherokee mine, which was closed down by order of the State mine inspector in July. Six shafts and three concentrating plants having a total capacity of 400 tons were operated by lessees of the Mexico-Joplin Mining Co. The most productive of these mines was the Bonnie Belle, and the other shippers were the Sweetheart, Sunny South, Gussie S., Westney-Foltz, and Allen. Nine shafts, one 150-ton mill, and 5 hand-jig plants were operated

by numerous lessees of the Sheridan Adams Royalty Syndicate. The 150-ton mill was that of the Pocatella Mining Co.

Nearly one-half of all the galena shipped was produced by lessees of the Frisco Mining Co., and a good output of sphalerite was also recovered. The 150-ton mill of the Missouri Mining Co. on the Frisco land was operated as a custom mill and several hand jigs were also used to concentrate the ore. Other producers in the district were lessees of the Alamo Land & Mining Co., the Napoleon Mines Co., the Wyatt Mines Co., J. A. Phillips, and the Joplin-Colorado Mining Co., also the Lucky Joe Mining Co., and the Goodrich Mining Co. There were several leases on the Colorado Joplin land, including the Last Chance, Mary Jane, and Clover Leaf mines, which were shipping considerable ore at the end of 1916.

*Spring City-Beef Branch district.*—The production of galena concentrates in this district decreased 228 tons in 1916 and the total value of the galena concentrates sold was $2,354 less than in 1915. The output of lead carbonate was small, as has been usual in recent years. The output of blende or mixed blende and zinc silicate concentrates was 1,130 tons less than in 1915, and that of zinc silicate 665 tons less. The value of the zinc concentrates decreased $105,880. No new concentrating plants were erected during the year, though quite a number of hand-jig equipments were provided by the small operators.

The smaller yield was mainly due to the decreased output of lessees on the Allen and the McCown lands. More than 50 per cent of all concentrates shipped was that of lessees of the St. Paul Mining Co. The Delta lease has been transferred to J. W. Creech & Co. Five shafts were used to hoist ore from different levels and a 150-ton mill was in operation. The Gypsey was the only producing mine on the T. L. Timmons lease, and the Jackson mine the sole producer on the Campbell lease. A more active drilling campaign is to be commenced by the St. Paul Mining Co., which owns large blocks of land in the Spring City district. The Onondaga mine was only operated to April, 1916, and the Hebaa mill on the Haines land from April to July, 1916. The Hebaa mine has been sold to W. G. Brady & Co., who are sinking the 140-foot shaft an additional 20 feet. A small quantity of lead and about 780 tons of zinc silicate was shipped by lessees of F. D. Bales, H. H. Beckwith, T. J. McKinney, Clark Craycroft, Harry Weymann, and the Zeta Land & Mining Co.

*Springfield district.*—The production of this district, in Greene County, in 1916, was 272 tons of galena, valued at $20,086, and 2,005 tons of sphalerite, valued at $156,169. The shipments of spalerite were 603 tons more than in 1915 and the total value of all concentrates shipped increased about $75,000. The ore bodies at the mines on Pierson Creek are in gumbo channels between limestone bars. The dirt containing pebble jack in the gumbo is spudded out, and drilling is not necessary except in sinking shafts or driving tunnels to reach parallel ore runs. Small boulders are generally mixed with the gumbo, and though these boulders contain no zinc they make the milling of the dirt much easier. Usually at the top and bottom of the gumbo there is a layer of galena and sphalerite. The roof is composed of limestone and little timbering is required.

The ore bodies all lie at about the same level and the depths of the shafts depend on the contour of the surface. The ore runs in the gumbo are frequently located by means of a core drill operated in the drifts.

The dirt yields an average recovery of more than 5 per cent in concentrates and frequently the recovery is more than 15 per cent. The zinc content of the sphalerite is between 62 and 63 per cent and the galena concentrates average from 81.5 to 83 per cent lead.

The larger part of the galena and sphalerite shipped in 1916 was from the Missing Link mine of the Choteau Mining Co., which mined ore from the 250-foot level by means of one shaft and concentrated it at a 100-ton mill. The gumbo ore run mined in 1916 was about 30 feet wide and 12 feet thick, and a crosscut was driven to a parallel run about 50 feet east, which was located by means of a core drill.

The second largest production was that of the Clark Mining Co. on the Fallin land. The two shafts at this mine are 140 feet deep and the mill has a capacity of 75 tons. Clark & Pursley also leased the old Daisy mine of the Bray Mining Co., at which they sunk a new shaft and connected it with the Bray mill by an inclined tramway. The Gem mine on the Parker & Cook land was bought by the Anna M. Mining Co., which produced some ore before the company was placed in the care of a receiver. Another producing property was the Bowyer mine of the Western Land & Mining Co., on the Dickensheet land, which is equipped with a 100-ton mill. There was no production made by C. B. Eslinger from the Webber land, although the property has a mill. Considerable drilling was done and a shaft was being sunk. Several cars of high-grade sphalerite concentrates were shipped from the Ayers Digging or Hoot Owl mine, which is located 7 miles northeast of the group of mines on Pierson Creek.

*Spurgeon-Seneca district.*—The total value in 1916 of the concentrates shipped from this district was $175,052, an increase of $93,392, compared with 1915, and the quantity of sphalerite concentrates shipped increased 949 tons. Nearly all the blende concentrates shipped were produced by the Quaker, Spurgeon Tiger, and Four Jacks mines, on the Bucklin & Wills land. The other producers were lessees working on the Aylor & Patten, H. E. Bucklin, Wills, Gilstrap, Granby, Edna E., and P. L. Swartz lands.

The old Bat mine on the Aylor & Patten land was unwatered in July, the old shafts were cleaned out, and a new shaft sunk. Six shafts in all were operated at different times, of which four were operated by sublessees. A good output of zinc silicate was made on hand jigs at the Bonnie Pearl Mining Co. lease of the H. E. Bucklin estate. The Spurgeon Tiger Mining Co. was much the largest producer in the district. Three shafts were in ore at the 70, 80, and 135 foot levels. The 135-foot shaft was sunk in 1916 and dirt was not hoisted through it until the latter part of the year. The old ground at the Quaker mine was abandoned, a new shaft was sunk about 900 feet southeast of the mill, and a tramway was built. The dirt milled was rich in concentrates and the recovery was large considering the short time the new workings were mined. A 100-ton plant was erected at the Four Jacks mine and a new shaft was sunk. Drilling showed an ore body at the 140-foot level, but the shaft was only down 65 feet at the end of the year. In addition to

the galena and sphalerite produced in 1916, a good output of high-grade zinc silicate was mined at the 45-foot level. O'Hara & Himmell produced galena and sphalerite concentrates by means of hand jigs from ore mined at the 160-foot level on the Wills land. The ore produced from the Gilstrap, Edna E., Williams, and Granby lands was zinc silicate or galena mined at shallow levels.

*Stott City district.*—The mines in this district which have been idle for several years produced sphalerite concentrates valued at nearly $50,000 in 1916. The production was from the Hill land, belonging to the Lawrence County Land & Mining Co., and the Stotts land, leased to the Algonquin Mining Co. The Maryland Zinc Co. milled some tailings at the old Gundling mine and its successor, the Spring River Mines Co., milled some ore which yielded concentrates having an average zinc content of about 61 per cent. The Algonquin Mining Co. mined ore from old pillars and drifts at the 188-foot level and milled the ore at a 175-ton concentrating plant built in 1916.

*McDowell and Stark City districts.*—The value of the lead, sphalerite, and zinc silicate concentrates shipped in 1916 from this district increased more than $35,000. The only producing mines at Stark City, in Newton County, were those of the Stark City Mining Co. and the Wild Rose Mining Co., on the K. D. F. Mining Co.'s land. Both companies mined galena and silicate ore bodies at the 76-foot level. A Keystone drill was purchased by the land owners and drilling was begun. The only productive mines at McDowell, in Barry County, were the Big Chance Mining Co.'s lease on the Henderson & Stuckey land, the Hubbard lease on the Hemphill land, and the old Springfield Fissure mine, which was reopened in 1916. The ore at the last-named mine is in gumbo runs, like those mined near Springfield, and the lead and zinc concentrates recovered at the old 200-ton mill were similar in grade.

*Wentworth district.*—This district had a much larger production in 1916 than in 1915, the value of the concentrates sold increased $275,000, and development was more active than in any of the small camps. The quantity of sphalerite sold increased about 3,900 tons and that of zinc silicate about 400 tons. The largest reported output was that of the D. & L. Mining Co. on the Baker land. This company, which is now known as the Georgette Mining Co., recovered about 4 per cent in sphalerite concentrates from dirt mined at 112 feet and treated at a 175-ton mill, which was operated steadily. The next largest output was that of the Smith & Hodges Mining Co., at the Jack Possum mine, on the Matlack land. The ore body mined lies at the 80-foot level, and the property is equipped with a 200-ton mill. The Turkey Point Mining & Milling Co., which treated old tailings from the Alice Dayton mine, was not operated continuously. The Ellwood mill of the East Hampton Development Co. has a capacity of 35 tons an hour and has a slime plant containing 5 James and 4 Arthbutnot tables. Ore at the 80-foot and 100-foot levels was mined through four shafts, and tramways 380 and 425 feet long were erected.

Both blende and zinc silicate concentrates were shipped from the Cotton Tail mine on the Lang land, owned by the North American Lead & Zinc Co. The 200-ton mill has been in steady operation since December, 1915. A part of the concentrates recovered is a mixed blende and zinc silicate. The 200-ton mill of the Molarkas Mining Co.

was not completed until October, 1916, but a good production was made during the two months it was operated. Two shafts, each 100 feet deep, were sunk and the ore was taken to the mill by means of two tramways which are each about 550 feet long. There was a small quantity of zinc silicate shipped from the Stinsonville section of the district, and several drilling machines were used in prospecting. A shaft was sunk by the Five Diamond Mining Co. on the Weygandt land. The Arista Mining Co. sunk 28 drill holes and 2 shafts on the Conway land. No ore was shipped in 1916.

*Christian County.*—There were a number of shippers of galena, sphalerite, and zinc silicate and carbonate in Christian County in 1916, and prospecting was active. The production amounted to 94 tons of galena, 100 tons of sphalerite, and 734 tons of zinc carbonate and silicate. The total value of all concentrates shipped was about $43,000. The sphalerite, most of the galena, and a considerable part of the zinc carbonate was shipped by the Ozark Mining Co. on the Bain land in sec. 36, T. 27 N., R. 21 W., where ore was mined at the 90 and 135 foot levels and milled at a 100-ton concentrating plant.

Another shipper of zinc carbonate was the Robertson Mining Co. in secs. 29 and 30, T. 27 N., R. 21 W. Most of the ore shipped was hand-cobbed carbonate taken from shallow levels. Part of the ore was treated by means of hand jigs, and a 150-ton mill was being constructed. Some drilling was done, and it is stated that a sphalerite ore body was struck at a depth of 90 feet which continued to the 180-foot level. The lessees on the Arnold land made the largest output of zinc carbonate concentrates. The Bray Mining Co. erected a 100-ton mill and did considerable development, though the ore mined was all taken from above the 40-foot level. The Bull Creek Mining Co. lease, also on the Arnold land, has a 60-ton mill which, owing to scarcity of water, was not steadily operated in 1916. Koerner & Co. worked in an open cut on Arnold land and shipped hand-cobbed concentrates. The Hobart Lee Tie Co. mined and shipped galena taken from shallow workings in sec. 11, T. 26 N., R. 19 W., and the Turkey Creek Mining Co. sank a shaft on the J. C. Bell land near Garrison. Some galena and sphalerite was shipped in 1916, but the work accomplished indicates a much larger production from these two mines.

*Ozark, Howell, Taney, and Stone counties.*—The production from these counties, which are in the southwest corner of Missouri, adjoining Arkansas, was 13 tons of sphalerite and 582 tons of zinc carbonate. Most of the ore shipped was from the Alice and the Southwest mines in Ozark County. The old Alice mine, owned by the Empire Zinc Co., was reopened by Nixon, Gunn & Brosius, and the 150-ton log washer was run on ore taken from an open cut 70 feet deep. The Southwestern Zinc Co. also mined zinc carbonate from an open cut in sec. 36, T. 23 N., R. 11 W.

The only shipment of concentrates reported from Howell County was a small quantity of zinc carbonate, which was shipped from Chapin by Allan Rowden. The small output of Taney County was a mixed blende and zinc carbonate shipped from the Josie B. mine on the Alnutt lease of the Jamieson land in sec. 35, T. 22 N., R. 21 W. A small experimental mill was used to mill the ore extracted by means of a 112-foot shaft. The erection of a 100-ton concentrating plant was commenced.

None of the mines in Stone County reported any shipment of ore in 1916, but considerable development was done by the Indian Creek Mining Co. and the Henrietta Mining Co. near Nauvoo, Mo., and the erection of concentrating plants was started by both companies.

*Zincite-Klondike district.*—The mines in this district include those in the territory south of Zincite, along the western border line between Missouri and Kansas and to the north of Smithfield.

In 1916 the total yield of galena concentrates was 139 tons and that of sphalerite was 7,278 tons, valued together at $573,128. The total value of the concentrates sold increased $116,042.

Many properties were opened and some new mills were built. The increased output was from small mines, and no large producing mines were developed. About 2,600 tons of the sphalerite was shipped from the Yellow Jacket, Locke, and Yellow Pup mines, near Smithfield. Yellow Jacket mine was the largest producer in this district. Fare & Graham operated the mill part of the year and milled ore at the Joplin Royalty & Mining Co. plant. Later a 100-ton mill was built by the Tennessee Lead & Zinc Co., which purchased the lease in July. The mine is near Spring River and was flooded twice in the first six months of 1916. Ore was mined at the 86 and 94 foot levels by means of two shafts, one of which was sunk in 1916. The output at the Yellow Pup mine was less than usual, owing to an extensive cave-in near the mill. Considerable drilling was done, but the ore deposits found were small. A new shaft was sunk at the Locke mine and 30 holes were drilled to a depth of from 80 to 110 feet. The old ore body apparently was worked out, and operations were suspended in July, 1916.

The production from the land of the Belville Land & Mining Co. was slightly larger than that of 1915. Two shafts were in operation, and a 100-ton tailing mill was operated by Lichliter & Co. The 100-ton mill of the Santa Barbara Mining Co. was mainly run on "dirt" mined by sublessees. A good prospect was opened by the Betsey Jane Mining Co. on the R. F. Brooks land, which had four shafts in ore and which erected a 150-ton plant. This mill was not operated until 1917.

The small production from the A. B. Brooks land was that of lessees, who milled at a custom plant ore taken from two shafts. The old mill of the Standard Hill Milling & Mining Co., operated by A. J. McElhenie, was used to treat tailings from the Campbell land. The Eaglewood mine on the same land had a small production, as it was not started until November, 1916.

The Sophia mine and mill on the Capitalista lease was run by the Elise Mining Co. and a good output was made at the 75-ton mill after it had been repaired. The only production from the Davison land was that of the W. H. Smith Co., which used hand jigs to treat the dirt mined.

The production on the J. Harry Linderman land was made by three mills from ore and tailings. The mill of the Lucky George Mining Co. has a capacity of 150 tons; that owned by Martin & Co., 100 tons, and that of the Independence Mining Co., 100 tons. A new 150-ton mill was built on the land of the Geneva Mining & Leasing Co. by the Queen Bee Mining Co. This plant was not operated in 1916.

The Big Stump lease of the Llewellen land had a good output of sphalerite, which was mainly shipped by the Munson Irwin Mining Co. and the Lucky Eight Mining Co. Five shafts were used to hoist ore, and the U. S. Paymaster Mining Co. was building a new 150-ton concentrating plant.

The Charles W. Edwards land was mined by the New England Zinc Corporation for a short time early in 1916, until litigation forced the lessees into bankruptcy.

Most of the output from United Zinc Co.'s land was that of the 1915 Mining Co., which sold its lease and 150-ton mill to the Vienna Mining Co. The old workings were abandoned and new ground was opened about 500 feet southeast of the mill shaft.

The 150-ton mill on the Parkinson, Graves & Harper land was used to mill tailings and custom ore from several lessees, including the Rich Hollow Mining Co. and the Bell Star Mining Co. The Geronimo mines were still hampered by an excessive quantity of water, but succeeded in producing a good output of sphalerite. One of the new operators in the district was the Ella May Mining Co., which sunk a shaft on the Wingert land and built a 150-ton concentrating plant. The Fighting Wolf Mining Co. on the White land mined some rich ore but a heavy flow of water and litigation delayed opening the ground. The production has materially increased since the company was placed in the care of a receiver.

Other producers in 1916 were lessees of the Missouri Hill Zinc Co. and the C. S. & P. Mining Co. on the J. H. Stephens land.

*Webb City-Carterville-Prosperity district.*—This district includes most of the original and typical "sheet ground" territory, and the larger output of concentrates in 1916 increased the value of the galena and sphalerite concentrates sold from $8,849,268 in 1915 to $11,681,850 in 1916. The output of the district naturally increased more rapidly than that of other districts, for there were many mines having large bodies of ore blocked out, and mills which had been operated single shift were worked double shift, or even continuously. Some new leases were developed but most of the production came from old properties. A good many new mills were completed or started prior to August, 1916, but when the price of concentrates declined to $65 and $70 few new investments were made. In common with other districts in the Joplin region the production was seriously handicapped by the shortage of electric power during the last three months of 1916.

The average recovery of galena and blende concentrates from crude ore mined from "sheet ground" was between 2.6 and 2.7 per cent for the period 1910 to 1914. It is generally believed that most mines having ore that yields between 2 and 2.5 per cent in concentrates were not profitably operated when blende concentrates sold for less than $45 or $50 a ton. At the abnormal prices paid for sphalerite concentrates in 1915, however, "dirt" which yielded 2 per cent in concentrates was profitable. Some of the mines milled "dirt" from "sheet ground" that averaged 1.7 per cent or slightly less, and the average recovery of concentrates from "sheet ground" in the district in 1915 was 2.32 per cent, of which 0.41 per cent was in galena concentrates. In 1916 the much higher costs of labor and of all kinds of mining supplies and building material made the mining

of "sheet ground" ore running less than 2 to 2.3 per cent in concentrates unprofitable unless the price of sphalerite concentrates was from $75 to $80 a ton. The average recovery of concentrates from "sheet ground" ore in the Webb City-Carterville district in 1916 was 2.14 per cent, of which 0.36 per cent was in galena concentrates.

Only a very small percentage of the district production is derived from "soft ground," and the prominence of the "sheet ground" mining is indicated by the fact that about 66 per cent of the total production of crude "sheet ground" ore came from this district. The recovery of galena concentrates in southwestern Missouri from ore mined in "sheet ground" was 28,077 tons, of which this district produced 19,947 tons. The quantity of zinc blende concentrates in southwestern Missouri derived from ore mined in "sheet ground" was 157,804 tons, or 57 per cent of the total zinc blende output of the entire State, and of this large quantity the "sheet ground" mined in the Webb City-Carterville-Prosperity district yielded 98,997 tons, compared with 81,933 tons in 1915.

The total production of lead concentrates in this district in 1916 was 22,231 tons, or 1,755 tons more than in 1915, and the value increased $868,678. The production of zinc blende concentrates in 1916 was 113,835 tons, an increase of 9,912 tons as compared with the output of 1915. The production from "soft ground" in the district was 2,284 tons of galena and 14,838 tons of sphalerite. The output from "soft ground" decreased about 30 per cent in 1916 and that from "sheet ground" increased about 19 per cent.

It is quite evident that the prosperity and the larger mining operations in the district are dependent on the price of zinc and lead concentrates being sufficiently high to permit "sheet ground" ore having a recoverable content of concentrates of 2 to 2.3 per cent to be treated at a profit. This was the case in 1916, except for about two months when some of the mines were operated at a loss. A comparison of the prices of various mining supplies in 1914 with those prevailing in the last part of 1916 and in 1917 has been made by W. B. Shackelford, of Webb City, showing the total average increase in costs to be about 95 per cent. The average per cent increase for some of the material and supplies used in mining and milling are as follows: Coal, 71 per cent; 80 per cent dynamite, 105 per cent; fuse, 53 per cent; caps, 92 per cent; screen jackets, 230 per cent; sheet steel spouting, 100 per cent; elevator cups, 133 per cent; hard iron jaws, shells, and plates, 80 per cent; belting, 30 per cent; rails, 129 per cent; track spikes, 107 per cent; solid drill steel, 120 per cent; hollow drill steel, 130 per cent; tool steel, 150 per cent; hammers, 103 per cent; bolts, 87 per cent; carbide, 10 per cent; wire cable, 80 per cent; nails, 125 per cent; babbitt, 76 per cent; jig wire, 40 per cent; wood pulleys, 40 per cent; oils, 21 to 81 per cent; galvanized iron, 186 per cent; gate valves, 50 per cent.

The following table prepared from data received from W. B. Shackelford, of Webb City, Mo., gives the quantity of ore (dirt) milled, the concentrates recovered, the value, assay, and cost of production of 32 mines in "sheet ground" in the Webb City-Carterville district in May, 1917. The first 13 mines produced zinc concentrates classed as high grade. The last 19 mines produced second or low-grade zinc concentrates.

*Statistics of sheet-ground mines, Webb City-Carterville district, Mo.*

**High-grade production and cost.**

| Dirt treated (short tons). | Production of concentrates. | | Gross value of concentrates. | Operating costs exclusive of royalty. | Assays of sphalerite. | | Lead content of galena. | Percentage of concentrates recovered from ore. | |
|---|---|---|---|---|---|---|---|---|---|
| | Zinc (short tons). | Lead (short tons). | | | Zinc. | Lead. | | Zinc. | Lead. |
| | | | | | | | | *Per cent.* | *Per cent.* |
| 23,950 | 391 | 27 | $33,840 | $29,898 | 60.10 | 0.20 | 76.26 | 1.63 | 0.11 |
| 14,557 | 294 | 8 | 22,237 | 19,376 | 60.74 | .20 | 70.32 | 2.02 | .06 |
| 13,730 | 236.76 | 45.7 | 24,759 | 20,753 | 62.65 | .15 | 77.45 | 1.72 | .33 |
| 20,853 | 239 | 35 | 21,696 | 23,642 | 61.11 | .43 | 73.80 | 1.15 | .17 |
| 23,299 | 302 | 40 | 26,606 | 26,606 | 59.83 | .46 | 73.95 | 1.30 | .17 |
| 14,243 | 219.50 | 72 | 24,991 | 16,242 | 61.30 | .20 | 79.50 | 1.55 | .50 |
| 11,223 | 170.80 | 29.18 | 14,795 | 15,168 | 61.58 | .20 | 72.67 | 1.60 | .17 |
| 7,180 | 115.20 | 10.76 | 10,268 | 9,532 | 62.00 | .20 | 70.00 | 1.62 | .14 |
| 10,965 | 8<br>243 | 14.50 | 20,943 | 18,079 | 60.76 | .19 | 65.10 | 2.29 | .13 |
| 7,071 | 139.59 | 11.89 | 12,913 | 9,928 | 63.00 | .20 | 78.95 | 1.98 | .17 |
| 12,352 | 230.75 | 7.69 | 19,925 | 16,218 | 63.00 | .20 | 73.45 | 1.87 | .06 |
| 7,766 | 93 | 5 | 7,675 | 9,739 | 61.50 | .20 | 67.00 | 1.20 | .06 |
| 11,061 | 142.92 | 144.40 | 27,835 | 13,541 | 60.80 | .17 | 80.00 | 1.29 | .43 |

**Second-grade production and costs.**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 28,827 | 589.60 | 55.00 | $48,005 | $33,748 | 58.00 | 0.30 | 72.00 | 2.04 | 0.19 |
| 14,967 | 262.45 | 47.61 | 24,709 | 24,203 | 60.40 | .75 | 74.00 | 1.75 | .32 |
| 14,458 | 245.54 | 47.01 | 23,390 | 22,565 | 61.45 | .45 | 75.00 | 1.70 | .33 |
| 10,260 | 131.50 | 32.00 | 13,450 | 12,142 | 57.00 | .50 | 75.00 | ..... | ..... |
| 21,568 | 414.00 | 30.70 | 32,797 | 25,463 | 58.90 | .50 | 75 | 2 | .15 |
| 10,800 | 31<br>192 | 12 | 17,328 | 12,695 | 60.50 | .50 | 74.50 | 2.07 | .11 |
| 10,344 | 106 | 20.40 | 10,296 | 8,085 | 59.00 | .50 | 75 | 1.02 | .16 |
| 14,110 | 180 | 41 | 17,668 | 12,540 | 60.25 | .31 | 70.45 | 1.28 | .29 |
| 13,652 | 313 | 26 | 26,777 | 18,936 | 59.25 | .45 | 79.10 | 2.30 | .19 |
| 19,643 | 281 | 61 | 28,425 | 22,618 | 61.60 | .50 | 78.50 | 1.45 | .35 |
| 7,282 | 182 | 47 | 17,356 | 10,957 | 55.00 | .50 | 80.50 | 2.55 | .65 |
| 5,281 | 93.30 | ..... | 5,484 | 7,138 | 55.63 | .50 | ..... | 1.60 | ..... |
| 1,325 | 71.68 | ..... | 5,750 | 4,335 | 59.40 | .20 | ..... | 5.40 | ..... |
| 2,037 | 111 | ..... | 7,304 | 4,948 | 52.20 | .50 | ..... | 5.44 | ..... |
| 20,892 | 200<br>450 | 39 | 50,000 | 36,143 | 58.00 | .18 | 78.00 | 3.12 | .18 |
| 8,327 | 103 | 44 | 12,596 | 11,795 | 55.40 | 1.80 | 84.00 | 1.11 | .53 |
| 22,124 | 285.84 | ..... | 21,296 | 27,082 | 60.50 | .37 | 80.00 | 1.29 | ..... |
| 31,199 | 399 | 339 | 66,580 | 39,352 | 52.25 | 1.60 | 82.71 | 1.28 | 1.09 |
| 10,897 | 172.42 | 78.60 | 19,636 | 14,097 | 55.40 | .56 | 82.35 | 1.58 | 2.30 |

This table shows that the mines producing high-grade concentrates, which were sold to smelters making rolled sheet zinc, treated ore which yielded 1.63 per cent in zinc concentrates and 0.19 per cent in lead concentrates, and that the average assay of the high-grade sphalerite concentrates was 61.41 per cent zinc, 1.87 per cent iron, and 0.23 per cent lead. When 10 per cent royalty on the gross selling price of the concentrates and 5 per cent for depreciation were added to the operating costs, the net loss of the 12 operators producing high-grade concentrates in May, 1917, was $681. The mines which produced second-grade zinc concentrates, which were shipped to smelters making prime western spelter, treated ore which yielded 2.24 per cent in zinc concentrates and 0.22 in lead concentrates. The average assay of the second-grade zinc concentrates was 58.38 per cent zinc, 2.46 per cent iron, and 0.52 per cent lead. The larger quantity of galena recovered at the 19 mines which produced second and low-grade sphalerite enabled them to make a profit of $33,677. This profit was due to the very high price paid for galena concen-

trates, which was more than $119 a ton, and the higher percentage of concentrates recovered from dirt treated.

Many of the old mines and mills have been described in former reports.

Lessees on the Guinn land reported the largest output of concentrates in the district. The capacity of the 12 concentrating plants on the land was in excess of 6,000 tons a day. The leasing companies that produced in 1916 were as follows: Electrical Lead & Zinc Mining Co., Ice Plant Mining Co. (mills 1 and 2), Walker & Co., Prigmore & Co., Mont B. Mining Co., Cunard Mining Co., Carmean & Squires (mills 1 and 3), Media Mining Co., Hurry Up Mining Co., Rollamo Milling Co., and Holmes Milling Co. Ore from "sheet ground" was treated at all plants except the two last-named mills. The only new mill erected was Ice Plant No. 2 on the old Premier tract. The Hurry Up mill was enlarged to make it capable of handling 1,000 tons of "dirt" daily, and other surface improvements were made.

Lessees on the Connor land at Prosperity were large producers of lead and had the second largest output of sphalerite. Some new leases were drilled, shafts sunk, and two new mills built. The shipments of concentrates from mines on the Connor land were larger in 1916 than in 1915 and some of the new mines opened proved to be very profitable. "Sheet ground" was mined by the Cumberland Mining & Milling Co., McDonald Mining Co., Cygni Mining Co., and Jasper County Mining Co. Eighty per cent of the lead and about 56 per cent of the sphalerite shipped was derived from "sheet ground." The concentrates from the Dixie, Seneca, Mary C., Victor, Tom C., and Ten O'Clock mines were mainly sphalerite derived from "soft ground." The Googie mill was operated for six months by the National Lead & Zinc Co. before being removed to Miami. The Tom C. and the Seneca mines developed by Thomas Coyne were sold to the Lincoln Zinc & Smelting Corporation. The mill on the lease was burned but it was promptly rebuilt. The old Victor mine was reopened by Thomas Coyne and brought to a producing stage late in the year. The old McDonald mine was sold to Aikin, Curtis & Cosden, and the McDonald Bros. Mining Co. opened a new mine on another lease of the Connor land, which was equipped with a mill.

The lands of the American Zinc, Lead & Smelting Co., as usual, were large producers of galena and sphalerite. The Davey mines Nos. 3 and 4 produced nearly all the concentrates shipped. The new 300-ton mill of the Queen Esther Mining Co., on American land, was completed, and large shipments of sphalerite having a zinc content of nearly 63 per cent were made.

The S. Y. Ramage lease, which is equipped with two milling plants, was, as usual, the principal producer on the Center Creek Mining Co.'s land. Other productive mines or mills were those of the Incline Mining Co., Carlat Mining Co., Jewell Mining Co., Aikins, Curtis & Cosden (Sunshine), J. R. Wisby & Co., Nearby Mining Co., and the Mercedes Mining Co. Six milling plants having an aggregate capacity of 1,500 tons (10 hours) are owned by the lessees. The only new concentrating plant built in 1916 was one of 150 tons capacity belonging to the Nearby Mining Co.

The producing mines on the Ware, Bowman & Scott land in the north Webb City section were the C. & S. No. 2 (old Princess), C. & S.

No. 4 (old Genessee), and the Wingfield. All were large producers from "sheet ground."

The output of the lessees of the Kelly Land Co. was slightly less than in 1915, and no new concentrating plants were erected. The principal lessees were the C. & S. No. 1 mine (old Imperial), the Cisco Mining Co., and the D. C. & E. Mining Co. on the Osceola lease. The largest producer on the Big Stick Mining Co.'s land was the Star Mining Co. The mill, which has a capacity of 450 tons, was overhauled and a 4-ton skip installed. The John L. mine is known as the No. 5 plant of the C. & S. Mining Co. The tailings at the Goode mine were rerun by the C. C. & H. Mining Co. The No. 2 plant of the D. C. & E. Mining Co., which has a capacity of 400 tons, was first operated in 1916.

On the Carter land, at Prosperity, "sheet ground" was mined at the Milan and Century mines. The Century or old Arkansas mill was transferred to Elliott & Banes, and the Milan mill was remodeled. Lessees of land controlled by the Zinc Corporation of Missouri were the third largest producers of sphalerite. The land was drained in 1915 and many leases given and mills erected. Both "sheet" and "soft ground" was mined and new mills were erected in 1916 on the Schenley lease (350 tons), Concord (250 tons), Cumberland No. 2 (250 tons), and Ben Franklin Mining Co. (200 tons). The larger producing properties on the different tracts of land of the 770 acres controlled by the Zinc Corporation of Missouri were as follows: Burgner tract, the Kirkwood Mining Co., the largest producing mine on the lease; Cornfield tract, Carmean & Squires Mining Co. No. 5, which was reopened after a long idle period; Ealor tract, the Broken Heart Mining Co., White Flint Mining Co., and Hill & Co.; Homestead tract, Cumberland Mining Co. No. 2; Luscombe tract, the Diamond Jack Mining Co.; Missouri Zinc Fields Co. tract, the E. D. Hornbrook Mining Co. (old Yale), the Ben Franklin Mining Co., the Bessemer Lead & Zinc Co., the Zinc Fields Mining Co., and Haney & Co.; McGregor tract, the Schenley Lead & Zinc Co.; South Carterville tract, Pinkard & Black, Jack Milling Co., and Wood Brown & Co.

On the B. C. Aylor land both "sheet" and "soft ground" was mined through five shafts by Marquis & Ball and by the National Lead & Zinc Co., which purchased the old McCorkle mine. A new 350-ton plant was built on the Steers & Rice land by the Franklin Lead & Zinc Co., which milled ore from "sheet ground" mined at the 200-foot level.

The Schoolhouse mine on the Chapman Bros. land was abandoned by J. F. Dexter in July. The 500-ton mill was remodeled after it was purchased by the Chapman Hosley Mining Co. The mine and mill were subsequently leased to the Roberta Mining Co. A mine which had a much increased output of both lead and zinc was that of the Orange Mining & Milling Co. on the Carterville Mining & Smelting Co.'s land. The ore milled was from "sheet ground," and the milling plant has a capacity of 250 tons. An unusually good production for a two-and-a-half-month's run was that of the Red Bird Mining Co. on the Chinn estate. This company reopened the old Endeavor mine south of Carterville and built a 500-ton mill. The Twin Cities Mining Co. was the largest producer of the various operators on the Eleventh Hour Mining Co.'s lease of the Chinn land. The new lessees on the James Luke land were the Latoka Mining Co., which moved a 200-ton mill from Thoms Station to its lease, and the

Mahatma Mining Co., which moved the old Hornbrook mill from Joplin.

The Bertha A. Mining Co. was, as in 1915, one of the largest producers of sphalerite in the Joplin region, and the milling plant of 1,000 tons capacity (24 hours) treated nearly 300,000 tons of ore. This plant is one of the most completely equipped in the district. A new concentrating plant, also of 1,000 tons capacity (24 hours), was erected by the Cisco Mining Co. on Royalty land west of Prosperity. The concrete hopper holds 1,200 tons of ore, and balanced skips are used to hoist ore from the 250-foot level. The production from this mine was comparatively small, because sufficient electric power was not available for operation after it was completed in September, 1916.

The Milton Mining Co. leased the Smith land and opened a good ore at a depth of 220 feet. A 400-ton mill was finished in September. The Baker land in the north Webb City section, owned by the Fremont Mining & Milling Co., was unwatered and a 400-ton mill was built by the Unity Mining Co. "Sheet ground" was mined and the output was good during the 40 days the mill was run in 1916. The Chapman Land Co. sunk 4 shafts on its fee north of Carterville. The 400-ton mill built in 1916 had a good production of sphalerite concentrates having a zinc content of about 62 per cent.

Some of the older producing mines, some of which were operated double shift and had a much increased output, were the Big Run Zinc Co., on the Ashcraft land; the Buelah S. mine, on the Bradford-Kansas City Mining Co.'s land; C. C. & H. Mining & Milling Co., on Rochester land; Old Staple Mining Co., on Underwriters' land; the Munson Mining Co., on Continental land; the Gobbler mine, on E. J. Chinn land; the Corona mine, on the General Lead & Zinc Co.'s land; Schoenherr Reynolds Mining Co., on the Pike Land Co.; Cygni Mining Co., on the Connor land; and W. E. Saum (old Troop) mine at Prosperity.

## CENTRAL AND SOUTHEASTERN MISSOURI.

The ore deposits of central and southeastern Missouri reach in a more or less connected belt from the region of Benton, Pettis, Morgan, Moniteau, Cole, and Miller counties on the northwest to the northern and eastern flanks of the St. Francis Mountains on the southeast. It is also true that there are scattered areas where more or less mining has been done all the way between the northwest end of this belt and the Joplin region, so that strictly speaking the lead and zinc deposits of Missouri practically form a zone around the northern half of the Ozark dome. A brief description of the ore deposits in central and southeastern Missouri is given in the separate chapter entitled "Silver, copper, lead, and zinc in the Central States in 1915," which can be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

The ore in the southeastern Missouri region is almost wholly lead, although a considerable zinc deposit occurs at Valle mines, some 6 miles north of the Bonneterre district, and a considerable quantity of zinc silicate is mined in various parts of Washington and Jefferson counties. A certain percentage of zinc is also found in the disseminated lead ore, the ore from one shaft being reported to run occasionally as high as 2 per cent of zinc for a week at a time. The zinc occurs more plentifully in the Leadwood-Flat River district and may

lie near the contact of the Bonneterre limestone with the Lemotte sandstone or some distance above it. In the lead concentrates zinc ranges from 1 to 5 or more. In the maximum proportions mentioned the zinc makes trouble in lead smelting, and for this reason some of the concentrating plants remove the zinc as a table middling.

Copper, nickel, and cobalt also occur in the ore, in considerable quantity in the vicinity of Fredericktown, and in small quantity, irregularly, in nearly all the deep mines. It is only near Fredericktown that the copper, nickel, and cobalt content of the ore has been the object of mining, yet a concentrate of these metals has been recovered as a table middling at several plants in other parts of the district, and 3,115 tons of copper concentrates were shipped in 1915 and 2,878 tons in 1916. These copper concentrates, from which 368,000 pounds of copper were recovered in 1916, were from the Federal, Mine La Motte, and St. Louis mines. In the disseminated ore district the production since 1869 increased rapidly and is estimated by Buckley to have amounted to 1,202,607 tons of lead concentrates, valued at $59,869,354, for the period between 1869 and 1906, inclusive. The mine production of southeastern and central Missouri has been reported to the United States Geological Survey since 1907.

*Mine production of lead and zinc concentrates in southeastern and central Missouri, 1907–1916.*

| Year. | Lead concentrates—galena. | | Zinc concentrates. | | | |
|---|---|---|---|---|---|---|
| | | | Sphalerite. | | Carbonate and silicate. | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| 1907 | 156,663 | $7,910,398 | 100 | $3,500 | 1,095 | $15,330 |
| 1908 | 183,095 | 6,906,116 | 42 | 1,050 | 1,369 | 20,436 |
| 1909 | 210,620 | 8,823,297 | 41 | 938 | 1,284 | 17,334 |
| 1910 | 210,890 | 9,360,309 | ..... | ..... | 929 | 19,000 |
| 1911 | 219,145 | 10,293,400 | 113 | 3,990 | 510 | 11,576 |
| 1912 | 218,803 | 9,849,854 | 40 | 1,292 | 1,051 | 21,020 |
| 1913 | 219,511 | 9,580,893 | 33 | 574 | 639 | 13,491 |
| 1914 | 249,165 | 9,710,125 | 40 | 700 | 497 | 11,282 |
| 1915 | 278,104 | 12,773,579 | 43 | 1,064 | 1,061 | 39,460 |
| 1916 | 307,025 | 20,720,737 | 365 | 14,400 | 1,030 | 42,129 |

A comparison of the estimates for the period of years to 1906 given by Winslow and by Buckley for Washington and St. Francois counties (which have supplied a very large per cent of the galena ores from southeastern and central Missouri) with the figures in the preceding table apparently indicates a production of galena concentrates during the last 10 years greater than the entire output of southeastern and central Missouri prior to 1907.

The lead ore of southeastern Missouri carries a small proportion of silver, the average being a very little over 1 troy ounce to the ton of lead concentrates. The resulting pig lead likewise carries silver, together with a little copper, nickel, cobalt, and traces of antimony and arsenic, and is sometimes commercially known as "Missouri chemical" lead in contradistinction to "Missouri soft" lead from the Joplin region. An average of about 15 per cent of the total lead concentrates from southeastern Missouri is desilverized The silver

so recovered does not pay for the refining charges, but the desilverized lead commands a slightly higher price, making up the difference. As the silver content of the concentrates is so small, it is disregarded in their sale, and therefore the smelter reports are relied upon for the silver production. As already explained, the quantity of silver produced during any year bears no direct ratio to the quantity of silver-bearing lead concentrates smelted during that year, for the reason that the silver bullion is stored and refined in batches at convenient times.

The silver output of Missouri in 1916 was derived almost entirely from lead concentrates, the only other source of production being a small quantity recovered from copper ore shipped from the Swansea mine in Ste. Genevieve County.

The silver production of southeastern Missouri was 129,450 fine ounces in 1916, as compared with 57,756 fine ounces in 1915, 61,168 fine ounces in 1914, 35,620 fine ounces in 1913, 34,438 fine ounces in 1912, 49,867 fine ounces in 1911, 33,096 fine ounces in 1910, 14,188 fine ounces in 1909, and 49,131 fine ounces in 1908. The silver production of 1916 was recovered from 88,081 tons of lead concentrates and from copper ore that averaged 6.6 ounces per ton.

The crude lead ore mined in 1916 amounted to 5,467,500 short tons, against 5,067,400 short tons in 1915, 4,718,300 short tons in 1914, 4,250,800 short tons in 1913, and 4,064,366 short tons in 1912. The crude ore in 1916 yielded 5.60 per cent of lead concentrates, which averaged 65.66 per cent of lead. The average value per ton of the lead concentrates in 1916 was $67.47, as compared with $45.89 in 1915, and the concentrates were slightly lower in lead content than in 1915. The output of galena concentrates was 307,025 tons, valued at $20,720,737, in 1916, against 278,104 tons, valued at $12,773,579, in 1915. As several of the large producers not only mine but also smelt their lead concentrates, the values given for concentrates are arbitrary to a certain extent. The galena concentrates produced in the southwestern Missouri region containing a higher lead content are mainly sold on bids from various purchasers, and the prices for those lead concentrates are not comparable with prices given for concentrates of the disseminated lead district.

*Analyses of ores mined in disseminated lead district in southeastern Missouri and of the various grades of resulting concentrates.*[a]

| | Ag | Cu | Pb | $SiO_2$ | Fe | $Al_2O_3$ | CaO | MgO | Zn | S | Ni and Co |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Ounces per short ton.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Ore (crude) | 0.12 | 0.06 | 5.7 | 5.0 | 4.1 | 4.9 | 25.5 | 14.2 | 0.8 | 2.0 | ..... |
| High-grade concentrates | 0.7 | 0.13 | 73.2 | 1.0 | 3.5 | ..... | 2.6 | 0.8 | 0.4 | 15.0 | 0.05 |
| Medium-grade concentrates | 1.3 | 0.12 | 68.6 | 1.4 | 4.6 | ..... | 3.1 | 1.4 | 0.8 | 15.5 | 0.06 |
| Low-grade concentrates | 1.0 | 0.30 | 65.8 | 0.5 | 3.1 | 0.5 | 4.3 | 2.8 | 1.7 | 13.7 | ..... |
| Flotation slimes, concentrates | ..... | 0.50 | 45.0 | 9.6 | 4.4 | 3.1 | 7.5 | 4.2 | 4.0 | 12.3 | ..... |
| Flotation slimes, high-grade concentrates | 3.7 | 0.05 | 57.8 | 6.0 | 2.7 | ..... | 2.2 | 1.4 | 9.4 | 15.5 | ..... |
| Joplin (southwestern Missouri) concentrates | ..... | ..... | 80.2 | 1.1 | 1.0 | ..... | 0.4 | ..... | 1.7 | 13.3 | ..... |

[a] Garlichs, Herman, Metallurgy of lead ores in the lower Mississippi Valley: Am. Inst. Min. Eng. Bull., July, 1917, pp. 1041–1046.

NOTE.—A typical analysis of southeastern Missouri undesilverized lead is as follows: Ag, 0.0080 (2.4 oz. per short ton); As, trace; Sb, 0.0030; Bi, trace; Cu, 0.0600; Fe, 0.0015; Zn, trace; Ni and Vo, 0.0080; lead by difference, 99.9995.

The production of sphalerite from central and southeastern Missouri in 1916 amounted to only 365 tons, valued at $14,400, which was considerably more than in 1915. The production of zinc carbonate from southeastern Missouri in 1916 amounted to 1,030 tons, against 1,061 (see p. 173) tons in 1915.

The output of lead recovered in mining shallow diggings in Washington and Jefferson counties was slightly less than in 1915, and the yield of lead and zinc from central Missouri was small.

Except in Morgan County, there was very little development of lead and zinc properties in central Missouri. A new concentrating plant was erected by the Federal Lead Co., a new turbine plant by the Doe Run Lead Co., the old Buckeye or North American mine was unwatered by the Missouri Cobalt Co., and the Mine La Motte was taken over by the Missouri Metals Corporation. As the miners received substantial bonuses based on the selling price of lead, labor conditions were generally satisfactory. Some of the men employed at the Federal and Doe Run mines went out in May, 1916, but the strike did not spread to other properties and the miners returned to work in less than 10 days.

## REVIEW BY COUNTIES.

*Cole County.*—No ore was mined at the Black Jack mine in 1916, which was reported to have been leased by the Consolidated Chemical Products Co. Galena ore mined by means of shallow shafts was shipped by Reuben Cole, of Russellville.

*Morgan County.*—The Bluff Spring Mining Co. opened an old mine in sec. 12, T. 44 N., R. 18 W., near Tipton, and shipped some sphalerite concentrates recovered in a small 100-ton plant. The ore milled was hoisted through a 149-foot shaft and the average zinc assay of the sphalerite concentrates was more than 62 per cent. The Pearce Mining Co. recovered both galena and sphalerite from levels between 30 and 80 feet at a mine in sec. 21, T. 42 N., R. 18 W. No concentrating plant was built and the sphalerite shipped was mine-run dirt having a zinc content of about 20 per cent.

*Washington County.*—Several companies owning large tracts of land in Washington County, such as the Washington Land & Mining Co., the Southeast Missouri Lead Co., and the Parole Mining Co., work their property on a royalty basis. The ore, which occurs at shallow depths and in association with barytes, is mined in a small way and at odd times by the barytes miners. This ore is all hand picked and cleaned, there being no concentrating plants. There are numerous other shallow lead and barytes diggings scattered over Washington County which are worked by small operators and farmers, who sell their product to the country merchants and to ore buyers. Much of this ore was purchased by Long & Evans, of Potosi, and P. G. Higginbotham, of Fertile.

Both galena and zinc silicate concentrates were shipped in 1916 by C. H. & J. Richeson, lessees of the Potosi Lead, Barytes & Mercantile Co. There are two shafts, one 55 feet deep and the other 85 feet deep on the Richeson lease, and the production of zinc carbonate was the second largest in southeastern Missouri. A small quantity of hand sorted copper ore was shipped by Jacob Baumgaertner from the

Racola mine. The mine was worked about 60 days and the ore was taken from shallow workings.

*Jefferson County.*—The Valle Mining Co., with offices at Valles Mines, in Jefferson County, operates, partly on a royalty basis, a large tract of land, about half of which lies in St. Francois County. The ores are galena and zinc carbonate and are found at depths ranging down to 225 feet, depending on topography. The yield of galena and zinc carbonate in 1916 was less than in 1915. Work in No. 5 shaft was discontinued in October after drifts on all levels and in all directions showed no ore. Two new prospect shafts have been started—one south and one west about half a mile distant from No. 5 shaft and in a new territory. The south shaft, called the "Butte," is connected by an air line with the compressor plant and is being sunk with jack hammers and a tugger hoist and is 150 feet deep. The other, called the "Bobcat," is being sunk by hand and is now 45 feet deep. The formations in both look promising and ore bodies should be encountered at depths of 175 and 80 feet, respectively. The Johnson shaft, operated by licensees, produced most of the carbonate during the year. Owing to the abnormal wages paid to laborers it has been difficult in 1916 to license or lease land to small mining operators.

The third largest output of zinc carbonate from southeastern Missouri was that of the Merseal Allee Timber Co., of De Soto. The ore, which was all hand cobbed, was taken from shallow workings. Surface mining was done on the Pinnell land at Fletcher by Johnson Bros., and small shipments of galena and zinc silicate were made.

*Ste. Genevieve County.*—No shipments of lead or zinc were reported from this county in 1916. Some hand-sorted copper ore which carried silver was shipped from the Swansea mine near Zell. The Cornwell copper mine was idle.

*St. Francois County.*—The St. Joseph Lead Co. (a description of whose mines, surface, and smelter equipment is given in the Central States report for 1912) reported the recovery of the largest quantity of galena concentrates from the southeastern Missouri region. Flotation is used in connection with both concentrating plants, which have a combined capacity of 4,000 tons a day. The ore treated in 1916 was hoisted from shafts Nos. 1, 2, and 12. Some drilling was done on the Puegnet 400-acre tract in West Bonne Terre.

The Doe Run Lead Co. operated four to six shafts during the year in the Flat River district. The 4,000-ton mill of this company is one of the best equipped in the district. The building is of steel construction throughout. The mill machinery is operated by alternating current 440-volt motors, which receive their current from the central gas-electric power station at River mines. All shaft equipment, such as hoists, compressors, underground pumps, are motor driven. Four 800-horsepower Snow twin tandem gas engines, direct connected, each with a 600-kilowatt generator, furnish power to all shafts and mill machinery. The gas-producer plant has four 800-horsepower Loomis-Pettibone producers and one 1,000-horsepower Westinghouse producer. A ball mill was installed in 1916 and work was commenced on a 6.000-kilowatt steam turbine plant which is expected to be completed in June, 1917.

The underground haulage at shafts Nos. 1 and 4 is done by air locomotives. At all other shafts mules are used.

The Desloge Consolidated Lead Co. in 1916 operated 3 shafts, 2 of which are about 300 feet and the other is 600 feet in depth. Two of the shafts are near the town of Desloge, but No. 4 shaft is near Leadwood. The concentrating plant is equipped with 2 Hancock jigs, 30 Wilfley tables, 10 Frue vanners, and appropriate rolls, Chile mills, and Dorr thickeners and flotation tanks. The capacity of the concentrating plant is 1,700 tons per day of 24 hours. Electric pumps were substituted for the steam pumps used underground. A steam turbine plant was installed and the capacity of the flotation plant was increased. The smelter near the concentrating plant is equipped with 4 Flintshire-Tarnowitz reverberatory furnaces, only 2 of which have been operated in recent years, the "gray" slag being sold to other smelters.

The mines of the St. Louis Smelting & Refining Co. are in the vicinity of the village of St. Francois, about 1 mile north of Flat River. Three shafts, from 208 to 565 feet deep, were in operation in 1916. The bottom of the ore was reached in shaft No. 6 at 540 feet and the Lamotte sandstone at 560 feet. The concentrating plant is modern, having a capacity of 2,500 tons per day of 24 hours, and is equipped with Hancock jigs, Overstrom classifiers and Butchart tables, and slime and settling tanks. A central steam-power plant drives air compressors and electric generators. The mill, hoists, and pumps are operated by electricity as well as the underground haulage and the trams for handling the ore from the shafts to the mill. This company also operates a lead smelter and refinery at Collinsville, and the lead concentrates produced by the mines and also those derived from crude ore purchased from the Baker Lead Co. were smelted at that plant.

The production of lead concentrates in 1916 was considerably larger than in 1915.

The Baker Lead Co., which owns the Jacob Day tract, blocked out a large quantity of ore by diamond drilling and shipped an increased quantity of ore to the St. Louis concentrating plant. The Boston Elvins Lead Co. purchased the Jones 40 acres at Elvins and nearly completed its 650-foot shaft. Equipment has been purchased and the mine will be producing in the early part of 1917.

The Federal Lead Co. operated 4 shafts during 1916, mining and milling 1,330,000 tons of crude ore. The capacity of the mill is 4,800 tons per day. The mill is equipped with 12 Hancock jigs, 72 tables, and 18 vanners, arranged in three units of two sections each. The equipment also includes regrinding rolls, elevators, and Esperanza-Federal drag classifiers. The final slimes are treated by flotation. The quantity of lead concentrates produced was approximately the same as in 1915.

During the year a second concentrating plant of 2,500 tons capacity per day was built to be served by the new No. 12 shaft which was sunk in 1915. The mill is most substantially constructed of reinforced concrete and steel; reinforced concrete was used also for the coarse and the fine ore bins. This mill, known as No. 4 mill, will begin operation early in January, 1917.

The mines and mills of the Federal Lead Co. are near Flat River, St. Francois County, Mo.

The Phoenix Lead Co. and the Fleming property in Madison County, near Fredericktown, were operated under lease throughout

1916 by the Federal Lead Co. Approximately 400 tons per day of crude ore were mined and milled.

*Madison County.*—Four shafts and several prospects were operated during 1916 by the Mine La Motte Co. on a tract which was first mined in 1720. The shallow deposits which were first worked were followed down to a depth of 100 to 125 feet, and from these levels the ore has been coming that for 50 years has supplied the mill and smelter. The mill, which is practically new, has a capacity of 800 tons per day of 24 hours, and is equipped with Hancock and Harz jigs and tables. The attempt was made some years ago to smelt the copper and nickel-cobalt sulphides, which in certain parts of the mines occur plentifully with the lead and are separated in concentration. Of late years these ores have been avoided and attention in mining has been limited to the lead ores, but the property has been acquired by the Missouri Metals Corporation, which will resume the mining and treatment of such ores. Large additions are being made to the equipment of the property, including a picking plant having a daily capacity of 7,500 tons, a 2,000-horsepower Diesel engine, and a concentrating plant designed for the treatment of copper-nickel-cobalt ores. A beginning was made on mining part of the ore by steam shovels and it is planned to use that method of mining entirely in the future.

The old Silver mine was reopened by the Madison Mining Co. and the surface equipment repaired. No production of copper or zinc was reported in 1916.

The Buckeye or North American mine, at Fredericktown, was purchased by the Missouri Cobalt Co. The mine is being unwatered and a concentrating plant is under construction.

## OKLAHOMA.

By J. P. Dunlop.

### PRODUCTION.

*Mine production of lead and zinc in Oklahoma in 1916.*

| District. | Ores. | | | | | | Metal content.[a] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lead concentrates (galena). | | Zinc concentrates. | | | | Lead. | | Zinc. | |
| | | | Sphalerite. | | Carbonate and silicate. | | | | | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| Ottawa County: | | | | | | | | | | |
| Miami | 15,145 | $1,271,382 | 52,946 | $3,960,029 | ..... | ..... | 11,970 | $1,651,860 | 27,532 | $7,378,576 |
| Peoria | [b] 138 | 8,028 | 41 | 2,513 | 312 | $14,886 | 98 | 13,524 | 123 | 32,964 |
| Quapaw | 61 | 4,379 | 1,986 | 149,536 | ..... | ..... | 47 | 6,486 | 966 | 258,888 |
| Murray County: | | | | | | | | | | |
| Davis | ..... | ..... | 151 | 6,645 | 197 | 10,735 | ..... | ..... | 133 | 35,844 |
| State total 1916. | 15,344 | 1,283,789 | 55,124 | 4,118,723 | 509 | 25,621 | 12,115 | 1,671,870 | 28,754 | 7,706,272 |
| 1915. | 9,269 | 506,369 | 28,412 | 1,911,402 | 172 | 5,666 | 7,306 | 686,764 | 14,314 | 3,549,872 |

[a] In calculating the metal content of the ores for assays allowance has been made for smelting losses in zinc but not in lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily spot quotations at New York and the value of the zinc from the average sales price of all grades reported by smelters.

[b] Includes a small quantity of lead carbonate.

The following table gives the output of crude lead and zinc ore for the whole State of Oklahoma, but it was thought advisable to calculate the tenor of crude ore and concentrates as well as assay content and value of concentrates separately for the Miami and Quapaw districts, inasmuch as the character of the ground operated in these districts differs so radically that general calculations for the State would be valueless:

*Tenor of lead and zinc ore and concentrates produced in Oklahoma, 1915 and 1916.*

| | 1915 | 1916 |
|---|---|---|
| Total crude ore milled in Oklahoma.....short tons.. | 891,800 | 1,406,900 |
| Miami district: | | |
| Total concentrates in crude ore— | | |
| Lead.....per cent.. | 1.10 | 1.15 |
| Zinc.....do.... | 3.28 | 4.03 |
| Metal content of crude ore— | | |
| Lead.....do.... | .86 | .91 |
| Zinc.....do.... | 1.82 | 2.33 |
| Average lead content of galena concentrates.....do.... | 78.9 | 79.0 |
| Average zinc content of sphalerite concentrates.....do.... | 55.7 | 57.77 |
| Average value per ton— | | |
| Galena concentrates..... | $54.60 | $83.94 |
| Sphalerite concentrates..... | $66.48 | $74.80 |
| Quapaw district: | | |
| Total concentrates in crude ore— | | |
| Lead.....per cent.. | .12 | .07 |
| Zinc.....do.... | 2.14 | 2.42 |
| Metal content of crude ore— | | |
| Lead.....do.... | .09 | .06 |
| Zinc.....do.... | 1.23 | 1.31 |
| Average lead content of galena concentrates.....do.... | 76.8 | 77.0 |
| Average zinc content of sphalerite concentrates.....do.... | 57.5 | 54.2 |
| Average value per ton— | | |
| Lead concentrates..... | $53.74 | $71.79 |
| Sphalerite concentrates..... | $80.97 | $75.30 |

The Oklahoma lead and zinc chapter in Mineral Resources for 1914 contains a brief history of mining in the various districts and also the estimated total production of each district, by years.

*Mine production of lead and zinc concentrates in Oklahoma, 1891–1916.*

| District. | Lead concentrates (mainly galena). | | Zinc concentrates. | | | |
|---|---|---|---|---|---|---|
| | | | Sphalerite. | | Zinc silicate and carbonate. | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| Peoria[a] | 2,032 | $95,198 | 97 | $3,129 | 2,555 | $66,793 |
| Quapaw | 3,621 | 222,079 | 30,655 | 1,311,276 | 164 | 2,692 |
| Miami | 57,486 | 3,463,971 | 177,673 | 8,837,646 | ..... | ..... |
| Davis | ..... | ..... | 558 | 27,399 | 755 | 20,395 |
| | 63,139 | 3,781,248 | 208,983 | 10,179,450 | 3,474 | 89,880 |

[a] Estimates for district incomplete, but are the best available.

The total value of the lead and zinc produced in Oklahoma in 1916 was approximately 120 per cent more than in 1915. This increase, though remarkable, does not fully indicate the notable development that occurred in the northern extension of the Miami field. It is

asserted that in no other mining district of equal area was so much development work done, drilling accomplished, and mining and milling equipment installed. An area of many square miles was dotted with drilling rigs, shafts, and concentrating plants under construction. Scarcity of labor and material, inadequate power, and in some places an excessive quantity of water tended to reduce the expected output of ore. Many of the new mills that were finished were operated only during the last months of the year, and it is reasonable to assume that the production in 1917 will be more than double that of 1916 and that the yield of ore from the Miami district will equal or exceed that of the Webb City-Carterville-Prosperity district of Missouri. Numerous ore bodies were developed by drilling, not only near the producing mines at Commerce, Cardin, Tar River, and Century, but also south and east of Century to Quapaw, and north, east, and west of Picher, in Oklahoma and Kansas. Nearly every tract of land north, west, and south of Baxter Springs, Kans., was leased, and every available drilling rig was put to work. The extension of the Oklahoma, Kansas & Missouri Railway was completed from Commerce to the Kansas line, and other railway extensions, including the Mineral Belt Railway, are under construction or contemplated, which will provide adequate transportation facilities for every part of the district.

It is impossible in a brief report to outline the work of development and construction accomplished or partly completed by the many large and small operating companies. That the expense of this work was justified on the whole is best indicated by the large output and prosperous condition of the producing properties. The town of Quapaw has grown rapidly, and there are more than 10,000 people residing at Century, Tar River, Picher, St. Louis, and other smaller villages and towns, which have all been located and built during the last two years.

The quantity of crude ore milled in Oklahoma increased from 891,800 tons in 1915 to 1,406,900 tons in 1916, notwithstanding that the quantity of ore milled by the old mines near Commerce was less in 1916 than in 1915.

The production of galena and zinc silicate in the Peoria camp was slightly larger in 1916 than in 1915, and a small quantity of sphalerite also was shipped. Many of the old mines at Quapaw were idle, but several tailing mills were operated, and the output was considerably larger than in 1915. Ore deposits are reported to have been located by drilling at levels lower than those worked in the old mines. Numerous transfers of land and leases have been consummated, and the camp was more active than it has been for many years.

The production from the Davis district, in Murray County, southern Oklahoma, in 1916, was about double that of 1915. No galena ore was shipped, but both sphalerite and zinc silicate were mined from shallow levels.

The value of the recoverable lead and zinc produced at mines in Oklahoma in the year 1916 was $9,378,142, compared with $4,236,636 in 1915. The metal content of lead concentrates increased from 7,306 tons, valued at $686,764, in 1915 to 12,115 tons, valued at $1,671,870, in 1916, and the recoverable zinc increased from 14,314 tons, valued at $3,549,872, to 28,754 tons, valued at $7,706,272.

In 1916 the lead concentrates produced in the Oklahoma districts were of slightly higher grade than those shipped in 1915. The

average metal content of the sphalerite concentrates from Miami ore increased from 51.8 per cent in 1912 to 53.6 per cent in 1913, to 54.8 per cent in 1914, to 55.7 per cent in 1915, and to 55.77 per cent in 1916, and was 3.5 per cent more than the average metal content of the sphalerite from the Quapaw district in 1916. The Quapaw production of sphalerite in 1916 was largely from tailings and the concentrates shipped had a lower zinc assay than in former years.

The lead concentrates from Oklahoma sold in 1916 were 6,075 tons more in quantity and $777,420 greater in value than in 1915. Miami district produced more lead than any district in the Joplin region with the exception of Webb City-Carterville, and its yield was equal to about 26 per cent of the production of the Joplin region. The Oklahoma shipments of sphalerite in 1916 amounted to 55,124 tons, valued at $4,118,723, an increase of 26,712 tons in quantity and of $2,207,321 in value.

The shipments of zinc carbonate and silicate increased from 172 tons in 1915 to 509 tons, valued at $25,621, in 1916. The Miami district yielded about 96 per cent of the sphalerite concentrates and more than 98 per cent of the galena concentrates sold in Oklahoma in 1916.

The lead and zinc deposits of northeastern Oklahoma, so far as known, are confined to the limits of Ottawa County and form the southwestern extension of the Joplin region. There are three camps, Peoria, Quapaw, and Miami, in this county, in which extensive mining has been done, and a fourth, the Sycamore Creek district, along the Seneca fault block from 2 to 3 miles southwest of Seneca, Mo., in which considerable prospecting has been done and some ore mined.

The lead and zinc deposits in southern Oklahoma are near Ravia, at the southeastern end of the Arbuckle Mountains and near Davis, Murray County, at the northwestern end of the same range. The Criswell silver mine, near Byars, in McClain County, which was idle in 1915, was reopened by Foster Bros., and a small quantity of ore was shipped to Omaha for smelting. The property is now owned by Carl Shuey.

## REVIEW BY DISTRICTS.

*Peoria district.*—Peoria is the oldest mining camp in the State, and galena and blende principally were mined in the beginning, but in recent years the small output has been mostly of carbonate and silicate ores. The estimated total production of zinc silicate concentrates for the period 1891 to 1916 is 2,555 tons and that of galena concentrates 2,032 tons.

Absence of railway transportation has retarded the development of the camp, and mining operations have always been intermittent. In 1907 a small mill was erected by the Chicago Syndicate Mining Co., and ore bodies were mined at the 140 and 160 foot levels on its property. The mill has never been run steadily, and very little prospecting for ore at deep levels has been done. The Lucky Six Mining Co. in unwatering a 160-foot shaft, which it proposes to sink to an ore body, located by drilling below the 200-foot level.

The largest producers on the Geboe land were the Gold Brick Mining Co. and the Nellie Bly Mining Co. Two shafts were in use to hoist ore from the 80-foot level.

There were quite a number of miners, of whom Sullivan & Sullivan were the largest shippers, working the shallow deposits of galena and zinc silicate on the Geboe, Ray, Helling, Scott, Charter, Mountjoy, and other lands in 1916. The aggregate shipments were 138 tons of lead concentrates, 312 tons of zinc silicate, and 41 tons of sphalerite, which were hauled to Galena, Kans., and Joplin, Mo.

*Quapaw district.*—The Quapaw district [1] mines extend from 1 to 4 miles east of Quapaw and from 5 to 7 miles south of Baxter Springs, Kans. The first shaft in the district was sunk in 1904 on the Abrams land.

Some shallow silicate and galena has been mined, but the chief production is blende and galena ores from sheet ground at a depth varying from 80 to 150 feet. This sheet is known as a blanket breccia, because the ore occurs in crevices and in the cement of the chert breccia and not between the chert sheets, as in the typical sheet ground of the Webb City (Mo.) district. The ore is associated with pink spar and jasperoid, but aside from the pink spar otherwise is similar to the "sheet ground" ores.

In 1916 considerable drilling was done east of Century nearly to the town limits of Quapaw and ore bodies were located at levels considerably lower than those worked in the old Quapaw mines. Some drilling was also done northwest of Quapaw to the Kansas-Oklahoma line and preparations were made to ascertain whether ore bodies similar to those mined at Picher, Cardin, and Century existed in the old Quapaw district. Development work was not active until late in 1916, and though there were some transfers of lands and leases the number of producing properties was not increased. The production was slightly more than in 1915, but it was largely from the treatment of old tailings. The sales of galena decreased from 82 tons in 1915 to 61 tons in 1916, and those of sphalerite increased from 1,478 tons in 1915 to 1,986 tons in 1916. The total value of the concentrates sold was $153,915, an increase of about $25,000. The estimated total production of the district to the end of 1916 is 3,621 tons of galena, 30,655 tons of sphalerite, and 164 tons of zinc silicate.

More than one-half of the production of sphalerite was shipped by lessees on the A. W. Abrams land, including C. E. Miller (Sunnyside and Last Chance mines), W. B. Bash (Lancaster mine), Bradley Lead & Zinc Co. (Red Wing mine), and the White Eagle Milling Co. The last-named company milled old tailings from which a recovery of about 1.8 per cent was made. The old Mission mill was moved to the Big Four mine by the Bradley Lead & Zinc Co. and mining was commenced about the end of the year. The ore mined at the Lancaster mine was treated at a custom mill.

The old Myrtle mine and 200-ton mill were only operated a short time in 1916 and the mill was removed in July. The production from the Sambo mine was small and an effort is now being made to develop ore at lower levels.

The Maybelle mill on the Ewart land was also moved off the lease after a short run early in 1916. The producing leases on the Petersburg land were the Cadillac Mining Co. and the Missouri, Kansas & Oklahoma Lead & Zinc Co., which operated the old Katy mill and drilled its lease. The only production from the Horse Shoe land

[1] Siebenthal, C. E., Mineral resources of northeastern Oklahoma: U. S. Geol. Survey Bull. 340, pp. 187-228, 1907; Zinc and cadmium: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 888, 1917.

was that of Baker & Co. on the J. P. McNaughton lease, but considerable drilling and prospecting was done by the Sequoyah Mining Co. The Timothy land was also drilled, and the Red Eagle land was leased to the Scott Eagle Mining Co., which sunk a shaft and cleaned some concentrates with hand jigs. The Hannibal St. Joe mine had a small production, and it is reported that some drilling was done which will result in the shaft being sunk to a much lower level.

*Miami district.*—A history of the mining in this district, including the output by years for the period 1908 to 1914, and the location of the mines and mills, was given in this report for the year 1914, copies of which can be obtained on request. The data given in the following reviews relate chiefly to production, new territory prospected, new mines opened, and new mills built in 1916.

Ore was discovered and the first shafts sunk at Miami in 1905–6, but development was not rapid until 1908. The ores are galena and sphalerite in about the proportion of one of the former to three of the latter, no oxidized ores having yet been found. The ores, as first mined in the vicinity of Commerce, occurred at a depth of 90 to 130 feet in sandstone breccias and in flint breccias lying below the sandstone. The sandstone was impregnated with a heavy oil, which, evaporating to asphalt, caused much trouble in saving the concentrates in that it balled up the ores on the jig beds and tended to float off the finer particles of ore. It also had a tendency to lower the grade of the concentrates by enveloping them in films of carbonaceous matter and so causing finely powdered marcasite and pyrite to stick to them. As the scope of mining operations widened and deepened, however, there was a noticeable rise in the grade of the concentrates. The average zinc content of the zinc concentrates sold in 1908 was about 49 per cent, whereas the average zinc content in 1916 was 57.77 per cent.

A brief description of the ore deposits in the Miami district of Oklahoma is given in the separate chapter of Mineral Resources entitled "Zinc in 1915," [1] which can be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

The mines of the Miami district in 1916 shipped 15,145 short tons of galena concentrates, valued at $1,271,382, and 52,946 short tons of sphalerite concentrates, valued at $3,960,029, an increase of 6,169 tons of galena concentrates and of 26,144 tons of sphalerite concentrates when compared with the output of 1915. As the average selling price of both lead and zinc concentrates was higher in 1916 than in 1915, the total value of the concentrates shipped from Miami in 1916 was $2,959,473 greater than in 1915. Of this increase, $2,178,208 was for sphalerite concentrates.

This unusual increase of nearly 100 per cent in the quantity of concentrates does not adequately show the extraordinary activity that prevailed in the district. No other mining district in the United States was so thoroughly prospected, nor had so many mines developed and concentrating plants erected. From an elevation the scene pictured resembled an oil region, for drilling machines and shafts dotted the prairie in all directions. Many drilling outfits were obtained from other States—some were shipped by express, so urgent was the demand. Prices paid for drilling advanced rapidly from 75 cents a foot to as much as $1.25 a foot.

[1] See also Siebenthal, C. E., Zinc: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, pp. 888–890, 1917.

After finding ore by scattered drilling operations, it is usual in the district to block out the ore by close drilling before erecting a mill, so that it was not uncommon to see four or five drills working on 1 acre of land. Sometimes two shafts were being sunk and a large concentrating plant was being built, so that the mill would be ready by the time ore was available for milling.

New towns followed the trend of development and the population of the camps north of Commerce increased by more than 7,000. A few of the main roads were put in good condition and the completion of the Oklahoma, Kansas & Missouri Interurban Railway from Commerce through Century, Cardin, and Picher to the Kansas line assisted in partly remedying poor transportation conditions. Another railway known as the Mineral Belt line was nearing completion in 1916. This railway runs from Quapaw to Century, Cardin, and Picher and will give good shipping facilities to the new mines developing east of Century. It is also proposed to extend it north into Kansas at least as far as Baxter Springs.

The production in 1916 was that of 25 mills in the old Commerce camp and 22 mills in the Picher, Cardin, and Century camps. Many of the mills in the last three camps were not operated until near the end of 1916, and as there were about 15 other mills under construction in 1916 and many others to be erected in 1917 it is probable that the output of concentrates in 1917 will again show an increase of at least 100 per cent. It is also certain that many of the new mines will be brought to the producing stage more quickly in 1917 than in 1916, for very few of the new plants are troubled by an excessive quantity of water. In fact it is stated that many mines will welcome pumping in order to obtain sufficient water for milling purposes.

The quantity of crude ore mined and milled increased from approximately 817,000 tons in 1915 to 1,314,800 tons in 1916. The percentage of concentrates recovered from crude ore milled was larger than in any other district in the Joplin region, and with increased operations in the northern part of the district the ore treated showed an increase in percentage of concentrates recovered from 4.38 per cent in 1915 to 5.18 per cent in 1916. The average increase in recovery from ore was larger than the figures indicate, for a considerable quantity of old tailings was rerun in the old Commerce camp. Many of the new mines in the Tar River and Century camps made recoveries as high as 10 to 15 per cent, and it is stated that the average yield of concentrates from the mines lying northeast of Commerce was between 7 and 8 per cent. As a larger proportion of the output of the Miami district in 1916 was derived from mines north of Commerce, which usually yield zinc concentrates of higher grade than those near Commerce, the average metal content of all blende concentrates sold increased from 55.7 per cent on 1915 to 57.77 per cent in 1916. The average metal content was 51.8 per cent in 1912, 53.6 per cent in 1913, and 54.8 per cent in 1914, so that the total increase in the zinc content of the sphalerite sold has been nearly 6 per cent in four years.

The separate assays reported showed the zinc content to range from 46.5 to 62.5 per cent, but most of the blende assayed between 53 and 58 per cent. Assays of 1,330 lots of zinc concentrates in 1916 by Thor Relling, of Miami, showed an average content of 57.10 per cent zinc, 2.25 per cent lead, and 1.45 per cent iron, and the average

content of 300 lots of galena concentrates assayed was 79.20 per cent lead, 2.60 per cent zinc, and 1.80 per cent iron. These assays reported by Relling very closely approximate the average lead content of galena concentrates and the zinc content of sphalerite concentrates given in the table for the Miami district, though his assays did not include any of the high-grade concentrates produced at the Picher mines. The average selling price of galena concentrates increased from $54.60 in 1915 to $83.94 in 1916 and that of blende concentrates increased from $66.48 in 1915 to $74.80 in 1916.

The recovery of galena concentrates from all the mines averaged about 1 ton to 3½ tons of sphalerite, which is much higher than in any other district in the Joplin region. The proportion of galena concentrates recovered from the "dirt" mined showed wide variations, ranging in different mines from 1 ton of galena to 30 tons of sphalerite to 1.2 tons of galena to 1 ton of sphalerite. The mines lying north and northeast of the Quapaw mine near Commerce reported 8,788 tons of galena and 35,222 tons of sphalerite, those lying southwest of the Quapaw mine to the southern limits of Commerce reported 6,282 tons of galena and 16,451 tons of sphalerite. The lowest proportion of galena to sphalerite was reported by the few mines at the extreme southwest corner of the district.

The most southwestern producting area in the Miami district is that lying about 1½ miles northwest of the city of Miami and locally termed the Horse Shoe Lake camp, first developed by McConnell & Barnes. Northeast of the group of mines at Horse Shoe Lake and southwest of Commerce is another less developed area on McCuddy Crang & Co.'s land. The combined production of these southwesterly mines in 1916 was 74 tons of galena, valued at $5,633, and 1,273 tons of sphalerite, valued at $111,069.

The McConnell-Barnes Mining Co. was the largest producer. In 1916 this company mined ore lying at the 218-foot level until June. The mine was then leased to C. L. Windbigler, who extracted ore from the upper level and treated it by means of hand jigs. The Denver Miami Mining Co. operated the McConnell lease of the McBee land lying northeast of the Windbigler lease. The 150-ton mill was run intermittently on ore taken from different levels as deep as 200 feet. A small mill was erected by the Greene Zinc Mining Co. on the McCuddy Crang & Co. land, but owing to an inadequate supply of water it was not operated in 1916.

The old mines at Commerce, the Mispah mine, the farthest south, those on the northwesterly ore run extending to the Vantage mine (old Haymaker), and those on the northeasterly ore run as far as the Quapaw mine are located on leases of the Emma Gordon Mining Co. and the Commerce Mining & Royalty Co. The production from this part of the Miami district in 1916 amounted to 6,282 tons of galena concentrates and 16,451 tons of sphalerite concentrates, having a total value of $1,678,021. Of this output the mines on Emma Gordon leases produced about 48 per cent of the galena concentrates and the mines on Commerce leases yielded more than 59 per cent of the sphalerite concentrates. The producers on Emma Gordon land that shipped concentrates in 1916 were the Standifer Mining Co., Carson Mining Co. (Oklahoma and Carson mines), High Five Mining Co., Prairie Mining Co., and Miami Zinc & Lead Co. Concentrates derived from tailings were also shipped by the Gartung Milling Co.

on the Prairie lease and by Theurer & Co. on the Carson lease. The Carson Mining Co. has been acquired by the Welch Mining Co. and has been subleased to the Haynes Mining Co., and the Prairie mine was transferred late in 1916 to the H. C. & S. Mining Co.

The productive mines on leases in the immediate vicinity of Commerce on land of the Commerce Mining & Royalty Co., were the Cactus (Tango shaft), Lost Trail, New State, Mizpah, Queen City-Joplin, Frosty Morning, Turkey Fat, King Jack (The Concentrating Co.), Never Sweat, Midas, Old Chief, Miami Amalgamated (Sullivan), and the Eureka, now called the T. H. C. Mining Co. Of these mines the Mizpah, Cactus, King Jack, Turkey Fat, and Never Sweat mines were operated by the controlling interests in the Commerce Mining & Royalty Co. In addition to running old tailings from the King Jack mine, the Worley Mining Co. cleaned out the mill shaft, hoisted dirt from the 133-foot level, and was preparing to mine at the 288-foot level.

The Haymaker tract on Commerce land, in the extreme northeastern section of the district, was operated until August, 1916, by the Vantage Mining Co. The Quapaw and Lennan mines on Commerce land, at the northwestern limits of the town of Commerce, were operated all the year. The deepest mining in the district was at the Lennan mine, where ore was taken from levels as deep as 385 feet. The Miami mine on Emma Gordon land and the Quapaw mine on Commerce land are the largest producers of galena in the older portion of the Miami district.

The nearest mine to Commerce, lying northeast of the Quapaw mine, was the Roanoke, where a shaft was sunk and a mill was under construction. About half-way between Commerce and Tar River the O. M. Bilharz Mining Co. made a large production from the Blue Bird and Short Horn mines. Ore was hoisted from four shafts from levels at about 270 feet. A new mill was finished at the Short Horn, and the lease was thoroughly drilled. Another mill has since been erected on the property. The Vinegar Hill Mining Co. drilled its lease on the Wilson land. Northeast of the Short Horn mine the Blue Goose mine, which was the largest single producing mine in the district, was operated by the Commerce Mining & Royalty Co. The dirt from this mine yielded more than 12 per cent in concentrates. The Keystone Tailing Co. also erected a mill to run the tailings from the Blue Goose mine. Shafts were sunk on the Blue Jay and Woodchuck mines, which are east of the Blue Goose. A 300-ton mill was erected at each property, but no concentrates were shipped in 1916. Other mines which were developed north of the Blue Goose and west of Cardin were as follows: The United States Smelting Co., which sunk two shafts each 173 feet deep and erected a 200-ton mill, which was completed in December, 1916; the Kitty Mining & Milling Co.; Velie Mine Corporation; and the Trustee Mining & Milling Co. There was a small production made by the United States Smelting Co., but the mills at the other mines were not completed in 1916.

The mines in the vicinity of Cardin or Tar River, lying west of Tar Creek, which produced lead or zinc concentrates in 1916, were the McConnell, the Beaver, the Bethel, the Croesus, the Lucky Bill, and the Tar Creek. Of these the Beaver mine, owned by the Commerce Mining & Royalty Co., was much the largest producer. The

old McConnell mine, which was the first developed mine near Cardin, was sold to the Miami Zinc Mines Co. The Sullivan Williams Royalty Co. now own the land on which the Lucky Bill Mining Co. (Cornfield), Bethel Mining Co., Croesus Mining Co., and Tar Creek Mining Co. are located. The mills at all four mines are of 200 tons capacity and were erected in 1916, except that at the old Cornfield mine. Other mills under construction on the lease were those of the Nihoma Mining Co. and the Domando Mining Co. Nine shafts were completed in 1916 and four others were being sunk. Nearly every lease in the neighborhood of Cardin was drilled, and mills were built early in 1917 by the Woodchuck Mining Co., Metal Milling Co., Rebekah Mining Co., Republic Mining Co., Nichols Williams Mining Co., and the Golden Rod Mining Co.

The entire production near the town of Picher in 1916 was that of the Eagle-Picher Lead Co., which had four mills in operation at the end of the year. The development and equipment of the Picher property entailed the expenditure of several hundred thousand dollars, and the plants are the most substantial and modern available and have separate sludge plants and Dorr thickeners and classifiers. All the ore was mined at about the 280-foot level. The names of the mills with the capacity of each are as follows: Whitebird mill, 175 tons, operated for twelve months; Crawfish mill, 200 tons, operated for seven months; Bingham mill, 200 tons, operated for four months; Netta mill (the largest in the Joplin region), 75 tons per hour, operated about four months. Two other mills, to be named the Goodrich and the Goodeagle, are being constructed. The Vantage Mining Co. moved its mill from the Haymaker lease, northwest of Commerce, to a lease on Picher land, southwest of the Netta mill. The average zinc content of the sphalerite concentrates from the Eagle-Picher Lead Co. mills was more than 60 per cent.

East and northeast of Picher many new companies discovered deposits of ore by drilling and were sinking shafts. Among the companies operating and building concentrating plants were the following: Lucky Jack Mining Co., S. Y. Ramage Mining Co., William F. White Mining Co., St. Louis Smelting & Refining Co., Provine Mining Co., Underwriters Land Co., Swartz Development Co., and Harmony Mining Co. West and northwest of Picher in Oklahoma a concentrating plant was completed in December, 1916, on the Gordon land, by the Walker Mining & Development Co., which was operated for a few days. The mill has a capacity of 250 tons and treated ore mined at a depth of 160 feet. New mines were also being developed and mills constructed by the Piokee Mining Co., National Zinc & Lead Co., Century Mining Co., and Dewdrop Mining Co.

The territory lying east of Tar Creek near Century and as far east as Quapaw was actively developed and practically all the land was leased. The mines from which concentrates were shipped in 1916 were the Underwriters, Admiralty, Lucky Kid, Montreal, and Welch. Other properties which were being developed and equipped with plants were the B. L. & G. Mining Co. (now owned by S. Y. Ramage), Potosi Mining Co., Buffalo Mining Co., Martin Mining Co., and Osage Mining Co. The Admiralty Zinc Co. has 5 shafts, the deepest of which is 215 feet, and 3 concentrating plants having a total capacity of 550 tons. Two of the mills were erected in 1916. The property is now controlled by Aikin, Curtis & Cosden. The Underwriters Land Co. completed and operated one 250-ton mill in 1916,

which milled ore hoisted through two shafts from the 110 and 130 foot levels. Two more shafts were being sunk on another lease and a 250-ton mill will be built. High-grade concentrates were produced at plant No. 1 and the recovery of concentrates from crude ore milled was nearly 10 per cent. The Lucky Kid Mining Co. also milled dirt that yielded about 10 per cent in concentrates. Ore was mined at the 146-foot level and concentrated at a 250-ton plant built in the spring of 1916. Only one shaft was used but another was being sunk and a deep well was driven to a depth of 920 feet to obtain a supply of water for the mill. The Welch Mining Co., which was the pioneer operator in the Century camp and which succeeded after an expensive struggle in lowering the heavy water and in sinking shafts to the 183-foot level, operated a 250-ton mill in 1916 and also completed a 500-ton mill in December. Both of these mills are on sec. 29 and another 500-ton plant is now being built on sec. 28. The Montreal mine had the distinction of producing more concentrates by means of hand jigs than any other mine in the Joplin region. The ore mined was very rich and a large part of it was loaded and shipped without treatment of any kind. The fine ore was recovered by hand jigs, and as no effort was made to make a close recovery the tailings milled at the 150-ton concentrating plant completed late in the year yielded a better recovery than the crude ore treated at many other mines. Two shafts were used to hoist ore from the 180 and 195 foot levels and another shaft was being sunk. Sixty-five holes were drilled, and it is stated that high-grade ore, sufficient to supply the mill for three years, has been blocked out.

The development work done in 1916 in the extension of the Miami district in that part of Cherokee County, Kans., lying north, northeast, and northwest of Picher, Okla., and in the vicinity of Baxter Springs is described in the Kansas section of this report.

*Arbuckle Mountain region.*—In the southern part of Oklahoma, in Murray County, 8 miles southwest of Davis and near the northwestern end of the Arbuckle Mountains prospecting and mining for lead and zinc has been prosecuted. The Arbuckle Mountains consist of a core of pre-Cambrian granite and diabase overlain by the Reagan sandstone, a formation of Upper Cambrian age, and that in turn by the Arbuckle limestone of Cambrian and Ordovician age, followed in order by the other formations of the Paleozoic in that province. The whole uplift is greatly faulted and, especially in the mining district southwest of Davis, is sharply folded. The ore deposits in the Davis area are found in the dolomitic Arbuckle limestone, generally in clay-filled solution channels. The zinc ore occurs as a carbonate from the surface to a depth of 5 to 8 feet. Below this level the zinc ore is the sulphide.[1]

Nearly all the ore has been taken from shallow workings, and none of the mining properties have been large producers. The first ores were mined in 1909, and small shipments were made during the next three years and also in 1915 and 1916. The total recorded production of the district, including 1916, is 558 tons of sphalerite and 755 tons of zinc carbonate.

The production in the Davis district in 1916 was 151 tons of sphalerite, valued at $6,645, and 197 tons of zinc carbonate, valued at $10,735.

[1] Snider, L. C., Preliminary report on the lead and zinc of Oklahoma: Oklahoma Geol. Survey Bull. 9, pp. 86-90, 1912.

A description of the region, the occurrence of ore, and the development of the then existing mines was given in this report in Mineral Resources for 1912.

A small quantity of sphalerite ore from the Morrison lease on the Butterly land was milled at the United Mining & Milling Co.'s plant. The Grace mine on the Morris land was operated by T. H. Slover and both sphalerite and zinc carbonate concentrates were recovered from ore mined at a depth of less than 20 feet. C. L. McGuire recovered a considerable quantity of zinc carbonate from open-cut workings on land owned by him in sec. 21, T. 1 S., R. 1 E. Zinc carbonate was also shipped by Ike Adler from the Dunn & Gillam land in sec. 28, T. 1 S., R. 1 E.

## WISCONSIN.

By J. P. Dunlop.

### PRODUCTION.

*Mine production of lead and zinc in Wisconsin in 1916, by districts.*

| District. | Ore. | | | | | | Metal content.[a] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lead concentrates (galena). | | Zinc concentrates. | | | | | | | |
| | | | Sphalerite. | | Carbonate. | | Lead. | | Zinc. | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| Benton-New Diggings | 2,182 | $149,029 | 103,247 | $3,917,127 | ..... | ..... | 1,589 | $219,282 | 29,572 | $7,925,296 |
| Cuba City | ..... | ..... | 3,992 | 102,083 | ..... | ..... | ..... | ..... | 752 | 201,536 |
| Dodgeville | 70 | 4,646 | 600 | 30,362 | ..... | ..... | 52 | 7,176 | 245 | 65,660 |
| Hazel Green | 174 | 9,764 | 22,411 | 772,692 | ..... | ..... | 102 | 14,076 | 5,897 | 1,580,396 |
| Highland | 238 | 16,140 | 867 | 45,000 | 3,270 | $49,675 | 188 | 25,944 | 789 | 211,452 |
| Linden | 623 | 42,390 | 15,743 | 455,578 | ..... | ..... | 454 | 62,652 | 3,827 | 1,025,636 |
| Livingston | 125 | 11,658 | 19,275 | 712,423 | ..... | ..... | 96 | 13,248 | 4,536 | 1,215,648 |
| Mifflin | 269 | 19,124 | 14,848 | 481,856 | ..... | ..... | 193 | 26,634 | 4,227 | 1,132,836 |
| Mineral Point and Montfort | 42 | 3,326 | 1,750 | 101,503 | 961 | 18,269 | 32 | 4,416 | 914 | 244,952 |
| Platteville and Potosi | 191 | 14,030 | 16,182 | 670,140 | ..... | ..... | 139 | 19,182 | 5,134 | 1,375,912 |
| Shullsburg | 273 | 21,290 | 2,305 | 106,845 | 30 | 600 | 198 | 27,324 | 910 | 243,880 |
| Total, 1916 | 4,187 | 291,397 | 201,220 | 7,395,609 | 4,261 | 68,544 | 3,043 | 419,934 | 56,803 | 15,223,204 |
| 1915 | 3,175 | 171,091 | 138,996 | 5,333,316 | 2,579 | 48,223 | 2,322 | 218,268 | 41,403 | 10,267,944 |

[a] In calculating the metal content of the ores from assays allowance has been made for smelting and concentration losses in zinc but not in lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily spot quotations at New York and the value of the zinc from the average sales price of all grades reported by smelters.

*Tenor of lead and zinc ore and concentrates produced in Wisconsin, 1915 and 1916.*

| | 1915 | 1916 |
|---|---|---|
| Total crude ore.....short tons.. | 1,934,000 | 3,066,500 |
| Total concentrates in crude ore: | | |
| Lead.....per cent.. | 0.16 | 0.14 |
| Zinc.....do.... | 7.32 | 6.72 |
| Metal content in crude ore: | | |
| Lead.....do.... | .12 | .10 |
| Zinc.....do.... | 2.65 | 2.26 |
| Average lead content of galena concentrates.....do.... | 73.5 | 72.7 |
| Average zinc content of sphalerite concentrates.....do.... | 36.5 | 34.4 |
| Average zinc content of zinc carbonate concentrates.....do.... | 24.9 | 21.0 |
| Average value per ton: | | |
| Galena concentrates | $53.88 | $69.59 |
| Sphalerite concentrates | $38.37 | $36.75 |
| Zinc carbonate concentrates | $18.70 | $16.32 |

The lead and zinc mines of Wisconsin are in Grant, Iowa, and Lafayette counties and comprise the most important part of the ore deposits of the upper Mississippi Valley region, a historical review of which is given in the Illinois section of this report in Mineral Resources for 1914. A detailed description of the Wisconsin lead and zinc districts and of the mines in each district to the year 1906 is given by Bain.[1] Although mining development has continued and many new mines have been opened, worked out, and abandoned, the area of the mining region has not been enlarged to any extent. The development of the mines subsequent to Bain's report and the output of Wisconsin mines have been given in the reports in Mineral Resources of the United States for the years 1907 to 1915.

The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age. The ores are galena, sphalerite or zinc blende, with smithsonite or zinc carbonate, the last locally known as "dry bone." As a lead region the district has been known from the earliest settlement days. In time the building of smelters near by made a market for the zinc ores. The first zinc ore to be mined was the carbonate found in association with lead in the shallow working above ground-water level. When all the main deposits were worked out down to water level there was a lull in mining in the region. Though the carbonate was known to give place to zinc blende and the lead to continue on below water, it was not deemed profitable to mine when continued pumping was necessary. About 1900 the higher price of zinc led to the opening of some of the deposits below water level, since which time zinc mining has increased until Wisconsin ranks among the largest of the zinc-producing States. The ore bodies are found in perpendicular, horizontal, or inclined cavities known as "openings" or "crevices," "flats," and "pitches." The openings sometimes extend for a considerable distance in a straight line called a "range," and may be mined at different places by different companies. When a range is once established it becomes an important guide in prospecting.

The galena of the district is nonargentiferous, and so far as known the zinc ores are free from cadmium. In some of the mines marcasite is so plentiful that the zinc blende concentrates are reduced to a very low grade. Owing to their nearness in specific gravity, marcasite and blende are very difficult to separate cleanly by hydraulic methods.

Roasting and electromagnetic separation have been utilized in the district for many years—and especially in the last two years—to produce a marketable zinc product. The green sulphide concentrates are roasted in cylindrical roasters to drive off a little sulphur and render the iron sulphide magnetic after which they are treated on electromagnetic separators and yield blende concentrates assaying from 56 to 60 per cent, and pyrites tailings, some of which are purchased by manufacturers of sulphuric acid. Comparatively few of the concentrating plants are equipped with roasters, but practically all the larger mining interests own or control separating plants. The number and location of such roasting and separating plants was given in the report for 1915. About 85 per cent of all the zinc concentrates produced in Wisconsin in 1916 were shipped to roasting and separating plants or were roasted at the mines before shipment.

[1] Bain, H. F., Zinc and lead deposits of the upper Mississippi Valley: U. S. Geol. Survey Bull. 294, pp. 81-148, 1906.

The average zinc content of the raw sphalerite concentrates sold in 1916 was 34.4 per cent and the average price per ton was $36.75; the corresponding content and price for 1913 were 38 per cent and $21.53; for 1914, 35.05 per cent and $17.73; and for 1915, 36.5 per cent and $38.37.

The percentage of concentrates recovered from crude ore is much higher than in the Joplin region, but the zinc concentrates average 20 to 24 per cent less in zinc content. On account of these conditions, at many mines no close recovery is made and the tailings, containing large quantities of zinc, are seldom reworked. The new concentrating plants are, however, being equipped with more tables than formerly. The concentrates from the tables have usually a very high iron content, but this can be remedied by roasting, so that such concentrates were profitable at the high price paid in 1915 and 1916.

The crude ore yields from 5 to more than 20 per cent of concentrates. The mining methods are largely determined by the mode of occurrence of the ores, but otherwise are similar to those in vogue in working the pockety ores at Joplin. The milling methods used in the Wisconsin field have been given by Walter Schultz,[1] of the Wisconsin Zinc Co.

The zinc carbonate ore, which is mined principally in the Highland and Mineral Point districts, is purchased mainly by the Mineral Point Zinc Co. and made into zinc oxide in the plant at Mineral Point, Wis.

The metal content of the raw sphalerite concentrates sold by the mines varied in 1916 from 20 to 57 per cent. The larger portion of the concentrates sold ranged between 27 and 44 per cent. The zinc content of the roasted sphalerite concentrates shipped varied from 56 to 60.6 per cent.

The value of the mine output of lead and zinc in Wisconsin for the year 1916 was $15,643,138, against $10,486,212 in 1915, an increase of $5,156,926.

The lead concentrates sold increased from 3,175 tons, valued at $171,091, in 1915 to 4,187 tons, valued at $291,397, in 1916. The sphalerite concentrates sold increased from 138,996 tons to 201,220 tons and the value of such concentrates increased from $5,333,316 to $7,395,609.

The quantity of zinc carbonate concentrates shipped increased from 2,579 tons in 1915 to 4,261 tons in 1916, and the value increased from $48,223 to $68,544.

The metal content of the lead concentrates in 1916 was 721 tons more than in 1915. The recoverable zinc content of the sphalerite and zinc carbonate concentrates in 1916 increased 15,400 tons.

There was a normal amount of development work done in nearly all districts; new mines were opened and milling plants were erected. The work accomplished in the New Diggings camp was, however, much greater than in other districts. At times the smaller mines found it difficult to dispose of low-grade ores, but at the end of the year the ore bins contained little more than the weekly output. Advancing costs and scarcity of labor were the principal obstacles to mining in 1916. The delay and loss occasioned by an inadequate supply of electric power was remedied by extensive additions to the plants which furnish power to the mines in the district.

[1] Schultz, Walter, Milling Wisconsin lead-zinc ores: Eng. and Min. Jour. July 14, 1917, pp. 82-84.

The controversy between the owners of mines at New Diggings and the Chicago & Northwestern Railway was finally settled by the State Railway Commissioner ordering the construction and maintenance of a branch line from Strawbridge to New Diggings, a portion of the construction expense to be paid by the mining companies interested The new branch will be of great benefit to the mines at New Diggings in saving the heavy expense involved in teaming concentrates and mill supplies over hilly roads. The mine owners had spent considerable money in making a rock road from the camp to Benton and were always willing to contribute a fair proportion of the cost of constructing the branch railway.

The Benton district was again much the largest producer of both galena and sphalerite concentrates, its output being almost five times that of Hazel Green, the next largest producing district. The mines in these two districts yielded about 60 per cent of the sphalerite and 64 per cent of the galena concentrates shipped by Wisconsin mines in 1916. The districts in Wisconsin that had a smaller production of zinc concentrates in 1916 than in 1915 were Livingston, Dodgeville, and Hazel Green. The quantity of ore treated was about 1,132,000 tons more in 1916 than in 1915, and the quantity of green sphalerite concentrates recovered was 44 per cent larger than in 1915. The average zinc content decreased from 36.5 per cent in 1915 to 34.4 per cent in 1916. The average zinc content of the carbonate concentrates decreased, and the average price decreased $2.38 a ton, but no fair comparison is possible, for the shipments in 1914, 1915, and 1916 included a large quantity of low-grade waste and sludge shipped from the Franklin and other mines at Highland. The galena concentrates sold in 1916 had a slightly lower lead content, and the average price was $15.71 more than in 1915.

The larger mining interests in the field, which include the Mineral Point Zinc Co., Wisconsin Zinc Co., Vinegar Hill Zinc Co., Cleveland Mining Co., Frontier Mining Co., and Field Mining & Milling Co., had a combined output approximately equal to 55 per cent of all the lead concentrates and 75 per cent of all the zinc concentrates shipped from Wisconsin mines in 1916. Mines controlled by Saxe, Pollard & Co., and Utt, Thorne & Co., contributed substantially to the output in 1916 and there were several new mines developed which had a good production.

The new development work done, the new producing mines, the new mills, and the transfers of ownership are set forth under the review by districts. For descriptions of the old mines and concentrating plants on which no essential changes were made during 1916, the reader is referred to the corresponding section of this report in Mineral Resources for 1914 and 1915.

## REVIEW BY DISTRICTS.

*Benton-New Diggings district.*—The Benton district produced about 52 per cent of the galena concentrates and 51 per cent of the sphalerite concentrates sold in Wisconsin in 1916. The quantity of galena concentrates was 501 tons more and that of zinc concentrates 36,562 tons more in 1916 than in 1915. The total value of all concentrates sold in 1916 was $4,066,156, against $2,676,387 in 1915. In addition

to the shipments of lead and zinc concentrates about 32,200 tons of crude marcasite and waste from separating plants were shipped. More new properties were developed and equipped in this district (with which are included the mines in that section called New Diggings) than in any other part of the upper Mississippi Valley region.

Several new mines were operated with local capital and some outside capital was invested in the district, but the increased production and development was mainly due to the extension of operations by the old campanies.

The largest quantity of sphalerite concentrates was shipped from the Champion, Kittoe, Thompson, Penna-Benton, and Calvert mines in the order named. As the zinc content of the sphalerite shipped from the district was as low as 20.1 per cent and as high as 46 per cent, the rank of the principal producing mines, according to value of output, was as follows: Thompson, Kittoe, Penna-Benton, Champion, and Calvert.

One of the largest and most complete surface plants in the district was reconstructed by the Field Mining & Milling Co. at the Thompson mine in the New Diggings camp. The new concentrating plant, finished in August, 1916, has a capacity of 40 tons per hour. The mill is electrically driven and is equipped with many innovations for this district, including a Dorr thickener and sludge tables. The jigs are arranged in parallel lines, and it is stated that this has resulted in an increased recovery of concentrates amounting to 15 per cent. Five drills were used for exploration work all year on the Thompson tract. The Crawhall mine and 20-ton (per hour) mill were also steadily operated. The Galena Refining Co., which is a subsidiary company of or affiliated with interests represented in the Field Mining & Milling Co., operated a roasting and separating plant having a capacity of 25 tons daily at New Diggings. A similar plant having a capacity three times as large was operated at Galena, Ill. Mathey kilns and Cleveland-Knowles separators are used at both plants.

The Acker Mining Co. continued drilling on the Gray land and sunk a prospect shaft. No output was made other than a small quantity of galena.

The Frontier Mining Co. was one of the largest shippers in the district. Ore was mined from the Bull Moose lease at the 175-foot level, and at the Midi mine at 100 feet. The 100-ton mill at the Midi mine was built in 1916 and operated for two months. The Midi mine is about 13,000 feet south of the Bull Moose and when operations were suspended in December, 1916, the shaft was deepened to 207 feet in order to open a deposit of sheet ore. The ore mined from the Robson lease in 1916 was from the workings of the original Calvert mine. A new range was opened by drifting from Calvert workings 175 feet north and 30° west. The Burrell Mining Co. recovered a good production of galena from shallow workings on the Calvert land. No pumping was done and no sphalerite was mined.

The Galenite mine on the Buxton land was prospected by means of shafts 16 and 26 feet in depth. This land was drilled about 1907 and had lain idle until 1916. R. E. Wilkinson drilled the Buckhorn land and sunk a 68-foot shaft to an upper run of ore. It is probable

that a small mill will be erected on the lease. The Sally Mining Co. sunk two 45-foot shafts on the Dawson land at New Diggings and built a 100-ton mill, which milled dirt having an average content of 12 per cent in 37.5 per cent sphalerite concentrates. The mine and mill are now controlled by the Vinegar Hill Zinc Co.

There was s small production of both galena and sphalerite from upper levels at the Grand View mine before it was taken over by Billingsley & Crafts, who prospected for ore lying at lower levels. The Indian Mound Mining Co., on the Monroe land, at New Diggings, had a good production of lead and zinc concentrates from ore mined at 118 feet. The mine and 150-ton mill are now owned by the Cleveland Mining Co., which owns other property in the Hazel Green district. The production of the Fox mine, belonging to the Mineral Point Zinc Co., was less than in 1915, but the output from the Penna-Benton mine, owned by the same company, increased almost 100 per cent. Both mines are equipped with modern mills. The ore at the Fox mine was extracted from the 180-foot level and that at the Penna-Benton mine from the 125-foot level. The lease on the Meloy land was thoroughly drilled and the cuttings indicated such rich ore that sinking a shaft and building a concentrating plant was commenced in December, 1916. This new mine is known as the Hoskins. A 150-foot shaft was being sunk on the McCabe land by the Domestic Mining Co., but no ore was hoisted in 1916.

One of the largest producers of both galena and sphalerite in Wisconsin was the Vinegar Hill Zinc Co. from the Wilkinson, Martin, Blackstone, and Kittoe mines. The Wilkinson is under lease to the Wilkinson Zinc Co., which has a new 75-ton mill. The Martin mine, which is equipped with a 200-ton (10 hour) mill, was steadily operated on ore from the 159-foot level. The Kittoe mine, equipped in 1915, had a large production which was only exceeded in 1916 by that of the Champion. The Blackstone mine at New Diggings, which was drilled in 1916, was equipped with a 200-ton mill which treated dirt yielding about 8 per cent in concentrates. A lease on the Meloy land was prospected with such favorable results that a shaft was completed in December and a new 200-ton mill was under construction. The mill on the Spenceley land, owned by the Longhenry Bros. Mining Co., recovered sphalerite concentrates having an average zinc content of 46.5 per cent. The ore mined at a depth of about 100 feet yielded about 8 per cent in concentrates. The Wisconsin Zinc Co. produced ore from the Winskill, the Champion, and C. A. Thompson mines, at New Diggings. The ore milled at the 200-ton Winskill mill was mined at a depth of 140 feet in "glass rock." Another run of ore was found 1,000 feet north of the present workings. The Champion mill, which was the largest producer of sphalerite in the New Diggings camp, treated ore taken from the 165-foot level. During 1916 a new body of ore was drilled out on the east end of the Champion lease. Drill prospecting at the present workings is stated to have shown ore in the "glass rock" below the floor of the level now worked that will greatly increase the life of the mine.

A new 200-ton plant on the C. A. Thompson land was completed late in the year, and some dirt hoisted from the 130-foot level was milled. A shaft was also sunk on the Murphy land lying west of the Thompson land. The ore from this new lease will be treated at the Thompson mill.

The Calvert lease was drilled and the development done showed that the ore body located on this lease extended to the Hoadley land on the west. There was no output from the Longhorn mine, but a 130-foot shaft was sunk and a 250-ton mill was built. The J. M. Thompson land, lying west of the Longhorn, was prospected and a shaft sunk. The ore from this land will be taken to the Longhorn mill by means of an aerial tram.

The Champion roaster at New Diggings has a capacity of 150 tons of raw concentrates a day. The equipment includes a Skinner type roaster and 8 Cleveland-Knowles separators. The Burr Mining Co. operated on the Treganza, Calvert, and Schultz leases. The 250-ton mill, which was improved by the addition of sand jigs, made a large output of both galena and sphalerite from ore mined at about 165 feet. The old Mathey roaster at Strawbridge, which was rebuilt in 1915, was operated by the Benton Roaster Co.

*Cuba City-Elmo district.*—No production of lead concentrates was reported in 1916 in this district, and that of sphalerite was 1,847 tons more than in 1915. Nearly all the output in 1916 came from the Lawrence mine of the Utt Thorne Mining Co. The 100-ton mill at this mine was destroyed by fire in August, 1916, and has not been rebuilt. A small quantity of ore from the Big Eight mine was milled at the old Roosevelt mill and Langendyke Smalley & Co. recovered some sphalerite by means of hand jigs at a prospect on the Carr land, which was afterward abandoned. The output from the Anthony mine, which was sold to the Standard Metals Co., was small.

The National Zinc Separating Co. operated 4 kilns and 13 Dings magnetic separators at Cuba City, treating more than 40,000 tons of green concentrates. The roasted concentrates shipped to smelters had an average zinc content of about 60 per cent. The plant was improved by the installation of gas-producing equipment. The Linden Zinc Co. operated the Campbell Separating Co.'s plant at Linden after June, 1916.

*Dodgeville district.*—The production of lead concentrates decreased in this district from 128 tons in 1915 to 70 tons in 1916, and the output of sphalerite decreased from 654 tons in 1915 to 600 tons in 1916. The Lucky Five Mining Co., on the Davis land and the Thomas land, was the only considerable producer of both lead and zinc concentrates. The Treweek shaft at this mine is 96 feet deep, the Davis shaft is 90 feet deep, and the concentrator has a capacity of 50 tons. Some prospecting was done and a new shaft was sunk at the Henry T. Roberts mine on the Berryman land. Sphalerite ore was mined by G. E. Williams from a depth of 60 feet, which yielded concentrates having a zinc content of 47.5 per cent. Other shipments of galena or sphalerite were made by Evans Bros., Davey & Evans, and P. Owens.

*Hazel Green district.*—Although there were only five producing properties in this district in 1916, the production of lead concentrates was 174 tons and that of sphalerite concentrates was 22,411 tons. The district has ranked second in point of production in Wisconsin for the last five years. The quantity of both lead and zinc concentrates shipped in 1916 was 8 per cent less than in 1915.

The Kennedy and the Lawrence mines were the largest producers. The Kennedy, which belongs to the Mineral Point Zinc Co., has been

worked for several years and its output was normal. The Lawrence output was much larger than in 1915. The Cleveland mine also had a large production and there were no material changes in the milling or mining equipment. The Federal mine of the Wisconsin Zinc Co. was operated part of the year before the mill was removed. A new 100-ton mill was built and operated by the Monmouth Zinc Mining Co., on the Barrett land, and the McMillan Mining Co. sunk a 168-foot shaft and built a 100-ton mill which was not operated in 1916. Development only was done by the Reo Mining Co. and Nolte Bros. Ore was discovered by the Vinegar Hill Zinc Co. on the Miller land. (This lease is now equipped with a mill—1917.)

*Highland district.*—The Mineral Point Zinc Co. controls most of the mining lands in this district and built a new 600-ton mill on the Eberle land. The only other concentrating plants in the district are a small one on the St. Anthony Mining & Milling Co.'s land, and one owned by the Lampe Highland Mining Co. The shipments in 1916 of all classes of concentrates were more than in 1915, though during a large part of the year there was little demand for low-grade zinc carbonate. The concentrates sold were, as usual, mainly composed of zinc carbonate, but some high-grade, hand-jigged sphalerite was sold by Frank Kroll. All the ore mined is derived from levels above 100 feet, and most of the shafts are less than 60 feet in depth. Other producers were the Web King Mining Co. and Blue River Mining Co., on the Beran land. No mining was done at the Highland mine and the carbonate shipped was from old dumps and sludge piles.

Among the producers of zinc carbonate were the Burrichter Mining Co., Blue River Mining Co., Web King Mining Co., Waters & Fecht, and lessees of the St. Anthony Mining Co.

A complete 600-ton (24 hours) concentrating plant was erected by the Mineral Point Zinc Co., but an adequate supply of water was not obtained for milling operations in 1916. The Lampe mine was purchased by the Saxe Lampe Mining Co., and ore mined at a depth of 80 feet was milled at a 100-ton plant which was started in October.

*Linden district.*—In 1916 the production of galena concentrates increased 233 tons, and that of sphalerite increased 8,468 tons, when compared with the production of 1915. The more than doubled output was due to the opening of new mines and to the large production from old properties.

The Optimo Mining Co. operated two shafts and a 100-ton mill at Optimo No. 2 on the Smith & Heathcock lease and also Optimo No. 3 mine and mill on the Rolling land. Active work at the Optimo No. 3 was not commenced until May, 1916. The Linden Zinc Co. treated the green concentrates from the Optimo mines and also custom ores at its plant at Linden.

The Campbell roasting and separating plant at Cuba City was purchased in October, 1916, so that the Linden Zinc Co. can now treat 115 tons of green concentrates daily. Some high-grade sphalerite concentrates were shipped by the Wickes Mining Co., which opened a new mine and built an 80-ton concentrating plant in 1916. Both lead and zinc concentrates were shipped from the old Hinkle mine, which was reopened by the Linden Development Co.

The production of the Spring Hill Mining Co. from the Heathcock lease was small, for the mine and 100-ton mill were not operated until

December, 1916. Two small mills were operated on the Ross land, one by the land owner and the other by the Stoner Mining Co. The output was large, considering the comparatively small quantity of dirt milled. One shaft and a 125-ton plant on the Smith land were operated by the Milwaukee Linden Mining Co. The production was one of the largest in the district. The mill at this property was destroyed by fire early in 1917. Heavy water encountered in the Weigle mine prevented the new owners, the Milwaukee Linden Mining Co., from hoisting ore from this mine. The Gilman mine, which was bought and equipped by the Linden Development Co., was steadily operated on ore taken from the 60-foot level. Some high-grade hand-cobbed sphalerite was shipped by Launder & Co., who reopened the Glanville, one of the oldest mines in the district.

*Livingston district.*—The production of sphalerite in this district decreased from 20,070 tons in 1915 to 19,275 tons in 1916, and the district was again the third largest producer of sphalerite in Wisconsin.

The Coker No. 1 and Coker No. 2 mines of the Mineral Point Zinc Co., the largest producers of both lead and zinc, were operated throughout the year. Both mines are equipped with a concentrating plant of 600 tons capacity (24 hours). The remainder of the output of the Livingston district was from the Rundell mine before it was closed and the mill removed. The Yewdale lease was drilled in 1916, a 151-foot shaft sunk, and the old Ellsworth mill was reconstructed. No ore was milled at the new property until 1917.

*Mifflin district.*—The output of Mifflin district in 1916 was 269 tons of galena concentrates, valued at $19,124, and 14,848 tons of sphalerite concentrates, valued at $481,856. The shipments of galena in 1916 decreased 38 tons, and those of sphalerite increased 6,349 tons.

Practically all of the production was from old mines, though several mines were operated by new owners. Some of the larger producers were the Grunow Mining Co., on the Bainbridge land; Lucky Six Mining Co. and the M. & A. Mining Co., on the Thomas land; the Peacock Mining Co., on the Jenkins land; the Shamrock Mining Co., on the Ross land; the Royal Mining Co., on the Ross land; the O. K. Mining Co., Wickes Mining Co., B. M. & B. Mining Co., and Phoenix Mining Co. Most of the ore was mined at depths of 55 to 115 feet, and most of the concentrating plants have a capacity of about 100 tons.

The Shamrock mine was abandoned in 1916, and the Peacock Mining Co. located a new range north of its present workings. The largest producer in the district was the B. M. & B. Mining Co., which operated the Squirrel mine on the Clark land, and the Biddick mine.

The value of the output of the Lucky Six Mining Co. was much larger than that of any other mine in the district. The shafts at this mine are 55 and 85 feet in depth. Only about one-third of the ore broken is milled, as the ore is culled under ground and the waste is piled up, confined by timbers, and used to support the roof of the drifts. There was a small output of hand-cobbed concentrates from the Slack mine before it was acquired by the New Phoenix Mining Co. The new owners did considerable development and built a 75-ton concentrating plant, which was not finished in 1916.

The old Senator mine, which had been worked by the Hump Mining Co., was leased to the Wickes Mining Co., which repaired the

mill and other surface equipment. The motive power was changed from steam to electricity and the entire plant made ready for mining and milling a much larger quantity of ore.

*Mineral Point district.*—All the concentrating plants in this district were idle in 1916, and the only production was that made by a number of small operators. Part of the concentrates came from that section of the district known as Barreltown, and the output was purchased by the Mineral Point Zinc Co. The average zinc content of the ore shipped was less than 28 per cent. The largest producers in 1916 were M. Minor, John Grange, Perry & Mitchell, Prince, Kinsman & Davis, Kinsman & Quick, Paulus & Co., F. & J. Ellsworth, Doney & Jackson, and Grange & Harvey.

The roasting and separating plant of the Mineral Point Zinc Co. treated more raw sphalerite concentrates than any other plant in the Wisconsin-Illinois region. Mathey roasters and Dings separators were used and the roasted concentrates shipped had an average zinc content of 55 per cent.

The McIlhon and Pierson leases have been taken over by Utt Thorne & Co. and preparations were made to reopen the old Harris mine.

*Montfort district.*—The shipments of sphalerite concentrates in 1916 were much less than in 1915. The O. P. David mine, operated by the Hump Development Co., produced nearly all the output of the district. The ore, which is of good grade, was hoisted by means of two shafts, each 140 feet deep, and was concentrated at a 60-ton mill. Some zinc carbonate concentrates were obtained at the Red Jacket mine from old dumps. The 200-ton milling plant was remodeled and a new shaft house and tramway built.

*Platteville and Potosi district.*—The mine production of this district in 1916 was twice as large as it was in 1915, amounting to 191 tons of galena concentrates and 16,182 tons of sphalerite concentrates. About one-third of the sphalerite was produced from the Hodge mine of the Vinegar Hill Zinc Co., and the remaining two-thirds from the East End, Climax, Bell, M. & H., Klar-Piquette, West Hill, Star, Wilson, and Blockhouse properties.

The old Hodge mine located on city lots in Platteville yielded a larger output than it had for many years. Only one shaft was used, and ore mined at 145 feet was treated at a 200-ton mill. The Homestead mine was operated until March, 1916, when it was abandoned. The surface equipment has been sold to Kistler & Stephens.

The third largest output of sphalerite was from the Klar Piquette mine, which has had a long record of production. In addition to the ore mined at the 150-foot level a considerable quantity of old tailings were rerun. The Wisconsin Zinc Co. failed to locate new ore bodies on the East End lease of the Seitz land and after a good output of ore, which yielded about 12 per cent in concentrates, the plant at the mine was dismantled. The Kistler Stephens Mining Co. operated the Homestead and the Enterprise roasting plants, which have a combined capacity of 27 tons a day. The output of the Bell Mining Co. was sphalerite concentrates containing an average zinc content of 56 per cent. The ore was mined at 110 feet and concentrated at a 100-ton plant erected in 1916. The Star Mining Co., closely affiliated with the Kistler Stephens Mining Co. operated the old Grant County

mine, from which ore was mined and milled until October, 1916, when the mine was shut down and the milling plant sold.

The West Hill Mining Co.'s lease on the Stephens and Hill lands, first developed late in 1914, was actively worked. The 50-ton mill made a good recovery from ore mined at the 100-foot level, and the sphalerite shipped had an average zinc content of 55 per cent.

A new corporation called the M. & H. Mining Co. developed a mine on the Loomis land and put in operation a 100-ton concentrating plant, built late in 1915. The quantity of sphalerite concentrates produced was comparatively small but the zinc content was greater than that of any other mine in the district. Development work was done by the New Rose Mining Co. on the Weigel land; three shafts, each 45 feet deep, were sunk, and a 50-ton mill was being built. The largest production from the new mines was that of the Blockhouse Mining Co. located on the Schroeder land. The 100-ton mill at this mine was first operated in 1916 and the dirt mined at the 150-foot level yielded a good recovery of both galena and sphalerite concentrates. The Wilson Mining Co. continued to operate the Preston Point mine at Potosi, producing both lead and zinc concentrates.

*Shullsburg district.*—The shipments of galena concentrates from this district increased from 110 tons in 1915 to 273 tons in 1916, and those of sphalerite from 656 tons to 2,305 tons. This large increase was mainly due to the new mine of the Oliver Mining Co. on the Mulcahy land. Large shipments of sphalerite were made during the last few months of 1916. The concentrating plant, which has a capacity of 300 tons a day and is driven by electric power, was erected in 1916. The Milwaukee Shullsburg mill on the Rowe land was burned after a short run in 1916. It is probable that a new mill will be erected by the Rowe Mining Co., which is now operating the mine. The old Rodham mine was operated by the Rodham McQuitty Mining Co. The mine yielded most of the galena shipped from Shullsburg district, as well as considerable sphalerite, which was all recovered from ore mined at the shallow depth of 35 feet.

The only other producing mine was that of the K. C. Jones Mining Co., which yielded a small quantity of galena. Twenty-seven holes, of which 19 were in ore, were drilled on the Copeland land by the Wisconsin Zinc Co. The lease will be developed, and the Birkbeck mill will be removed from Galena to the new property.

## UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS ON GOLD, SILVER, COPPER, LEAD, AND ZINC IN THE CENTRAL STATES.[1]

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[1] The publications for which a price is given are no longer available for free distribution but can be purchased from the Superintendent of Documents, Washington, D.C.; others can be obtained free on application to the Director of the United States Geological Survey. Some are out of print but may be examined in libraries.

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# BAUXITE AND ALUMINUM.

By JAMES M. HILL.[1]

## BAUXITE.

### INTRODUCTION.

Bauxite, the ore of the widely useful metal aluminum, has also an important use in the manufacture of artificial abrasives and of bauxite brick, more properly called high alumina refractories. It is also the basis of an extensive chemical industry, being the crude material from which alum, aluminum sulphate, and several other aluminum salts are made.

### DOMESTIC PRODUCTION.

The production of bauxite in the United States in 1916 was 425,100 long tons, having a value at the mines of $2,296,400, an increase over the production in 1915 of 43 per cent in quantity and 52 per cent in value. The production from the Georgia, Alabama, and Tennessee field in 1916 was 49,190 long tons, an increase of about 74 per cent, and the Arkansas production of 375,910 long tons showed an increase of approximately 40 per cent.

Apparently the producers of aluminum consumed about 300,000 tons, makers of chemicals about 80,000 tons, and makers of abrasives and refractories about 45,000 tons of bauxite in 1916.

As will be seen by the following table, though the domestic consumption of bauxite in 1916 also increased 43 per cent over the consumption in 1915, domestic deposits were apparently able to supply the whole demand and still leave some bauxite for export. The larger exports were apparently to Canadian aluminum and abrasive makers.

*Bauxite produced and consumed in the United States, 1912–1916.*

| Year. | Domestic production. | | | | | |
|---|---|---|---|---|---|---|
| | Georgia, Alabama, and Tennessee. | | Arkansas. | | Total. | |
| | Quantity (long tons). | Value. | Quantity (long tons). | Value. | Quantity (long tons). | Value. |
| 1912 | 42,566 | $191,348 | 117,299 | $577,584 | 159,865 | $768,932 |
| 1913 | 40,370 | 150,710 | 169,871 | 846,988 | 210,241 | 997,698 |
| 1914 | 24,071 | 92,508 | 195,247 | 976,686 | 219,318 | 1,069,194 |
| 1915 | 28,245 | 144,345 | 268,796 | 1,370,489 | 297,041 | 1,514,834 |
| 1916 | 49,190 | 284,810 | 375,910 | 2,011,590 | 425,100 | 2,296,400 |

[1] The statistical data in this report were prepared by Miss H. M. Gaylord, of the United States Geological Survey.

*Bauxite produced and consumed in the United States, 1912–1916*—Continued.

| Year. | Imports. | | Exports.[a] | | Domestic consumption. | |
|---|---|---|---|---|---|---|
| | Quantity (long tons). | Value. | Quantity (long tons). | Value. | Quantity (long tons). | Value. |
| 1912 | 26,214 | $95,431 | (b) | (b) | 186,079 | $864,363 |
| 1913 | 21,456 | 85,746 | (b) | (b) | 231,697 | 1,083,444 |
| 1914 | 24,844 | 96,500 | [c] 5,374 | $240,084 | 238,788 | 925,610 |
| 1915 | 3,420 | 17,107 | 16,082 | 717,186 | 284,379 | 814,755 |
| 1916 | 30 | 87 | 18,032 | 987,454 | 407,098 | 1,309,033 |

[a] Includes bauxite concentrates.
[b] Included in "All other articles."
[c] From July 1, 1914, includes bauxite concentrates.

## MARKET AND PRICES.

The market for bauxite in the United States is east of Mississippi River, and the largest consumers are located at or near the following cities: East St. Louis and Aurora, Ill.; Detroit, Mich.; Cincinnati, Ohio; Knoxville, Tenn.; Philadelphia and Erie, Pa.; Niagara Falls and New York City, N. Y.; and Boston, Mass. Recently a number of municipal and industrial waterworks have installed small plants for the manufacture of aluminum sulphate for use in purification of water. It is not believed that this new market will materially affect the industry, as it seems probable that its demands will not be great and that the bauxite used may be of lower grade than that accepted by commercial manufacturers.

Bauxite is graded according to its chemical composition and sold to the various consuming industries on the basis of analysis. Apparently, low silica and titanium content is essential to the aluminum industry, but the iron content may be fairly high, though bauxites low in iron and titanium are preferred by the makers of alum and aluminum sulphate. Makers of abrasives appear to be able to use bauxites lower in grade and containing larger proportions of silica and iron than are permissible in bauxite for other uses, but the majority of abrasives are made from bauxites low in silica and iron. The bauxite used for refractories must apparently be fairly low in iron.

The prices received for bauxite in 1916, as reported by producers, ranged from a low of $4.25 to a high of $6.25 a long ton, the average price for the whole production in 1916 being $5.40 a long ton. During the latter part of the year and early in 1917 higher prices were offered for good grade bauxite from the central Georgia field.

Owing to the freight embargoes placed by various railroads in the last half of 1916 and also to the shortage of cars the producers of bauxite had considerable difficulty in meeting their orders. The exceptionally wet winter was also a handicap to regular production and shipping and, at a few pits in the central Georgia field, work had to be stopped on account of difficult mining or hauling conditions.

## WORLD'S PRODUCTION.

As will be seen from the following table the production of bauxite in all countries is increasing. Data on the output of the French

mines have been withheld since the beginning of the war, but it can not be doubted that the production from these deposits has not diminished.

*World's production of bauxite, 1912–1915.*

| Country. | 1912 | | 1913 | | 1914 | | 1915 | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (long tons). | Value. | Quantity (long tons). | Value. | Quantity (long tons). | Value. | Quantity (long tons). | Value. |
| United States | 159,865 | $768,932 | 210,241 | $997,698 | 219,318 | $1,069,194 | 297,041 | $1,514,834 |
| France | 254,851 | 507,649 | 304,407 | (a) | (a) | (a) | (a) | (a) |
| United Kingdom | 5,790 | 6,881 | 6,055 | 7,606 | 8,296 | 10,507 | 11,723 | 15,393 |
| Italy | 6,596 | 20,618 | 6,843 | 16,101 | 3,844 | 9,046 | 6,504 | 15,942 |
| India | 950 | 2,511 | b 1,184 | 161 | b 514 | 156 | (a) | 141 |
| | 428,052 | 1,306,591 | 528,730 | ..... | ..... | ..... | ..... | ..... |

a Statistics not available. b Used only in manufacture of cement.

Little has been heard from the South American deposits, though it is known that some of them are under development by United States capital, and that early in 1917 a cargo of Guiana bauxite was received in an American port. From what information is available it would seem that these extensive deposits of good-grade ore may have a considerable influence on the future of the domestic bauxite mines.

It has recently been announced that concessions have been given for the development of bauxite deposits in India. There are known to be large bodies of high-grade bauxite in India, particularly on the Baihir Plateau in the Balaghat district and near Katni in the Jubbulpore district.

## OCCURRENCE AND CHARACTER OF BAUXITE IN THE UNITED STATES.

The known commercial bauxite deposits of the United States are in Cherokee, Calhoun, and Dekalb counties, Ala.; Saline and Pulaski counties, Ark.; Wilkinson, Meriwether, and Sumter counties, Ga.; and Hamilton and Carter counties, Tenn.

Clays carrying a large amount of alumina are known in many States, notably central Pennsylvania, northeastern Kentucky, central Indiana, east central Missouri, in the Cretaceous areas of Texas and Alabama, and in the West Coast States. These clays so far as known do not have the characteristics of American bauxite and are not sold as such, though the clay from some of the deposits is used for the manufacture of "high alumina refractories."

All the bauxite mined in the United States is closely associated with kaolin. In the Arkansas field the kaolin is derived from the alteration of syenite in place. In the Tennessee and north Georgia-Alabama fields the origin of the kaolin is not so clear, but it has been formed along faults possibly by the action of circulating waters on the limestone, shale, and quartzitic rocks. In the central-Georgia field the sedimentary kaolins are widespread and were laid down by Cretaceous and Tertiary streams which obtained the materials they carried from the deeply weathered crystalline rocks of the Piedmont region.

In most places there is a distinct gradation from unaltered kaolin through bauxitic kaolin, in which there is a suggestion of pisolitic growth, to bauxite composed entirely of hard pisolites.

Bauxite is not a distinct mineral but rather a rock composed of at least two and possibly three hydrates of alumina, ranging from diaspore ($Al_2O_3.H_2O$) through theoretical bauxite ($Al_2O_3.2H_2O$) to gibbsite ($Al_2O_3.3H_2O$), iron oxide, water, and silica, and more or less titanium oxide and clay.

The bauxite from all localities in the United States, though it may vary in chemical composition, is on the whole similar in general appearance, with the exception of the "granitic bauxite" of the Arkansas field. The greater part of the American bauxite appears to be made up of rounded pebblelike bodies set in a fine-grained matrix, which may also consist of small rounded particles or may be as fine grained as the finest clay. The pebble or pisolite form is so general that it is the conspicuous characteristic of American bauxite.

The pisolites vary in diameter from a small fraction of an inch to as much as 2 inches, but generally they range from one-fourth to three-fourths of an inch. They are not pebbles in the ordinary sense, as their shape is not due to rounding by running water. The pisolites, when sliced and examined under the microscope, are seen to be made up of concentric layers of amorphous material and are cut by veinlets of a crystalline aluminum mineral. In some deposits the pisolites are hard, in others soft, but it appears to be generally true that the hard pisolite ore is of better grade than the soft.

The matrix of the bauxite in some deposits is soft and claylike, while in other places it is hard and flinty.

The color of American bauxites ranges from light cream through various shades of brown to a deep brownish red, depending on the quantity of iron contained. However, the color is not always a guide to the iron content for some brown or red bauxites are low in iron, the iron being only a stain on the surface and not penetrating the interior of the pisolite.

There is only one way to determine the value of bauxite and that is by chemical analysis, which should show total silica, alumina, titanium oxide, iron oxide, and water. Bauxites of commercial grade should carry at least 52 per cent alumina, though much of that shipped contains from 58 to 65 per cent $Al_2O_3$, and some material as low as 42 per cent $Al_2O_3$ is mixed with higher grade ore to bring the average up. Silica and iron should not run above 15 per cent, and the better grades of bauxite contain as low as 1 per cent iron and 3 to 5 per cent silica. Titanium is objectionable, and the content should be below 2 per cent, though much of the central-Georgia bauxite carries nearly 3 per cent $TiO_2$. The combined water of American bauxites ranges from 15 to 33 per cent. Some of the Arkansas and central-Georgia bauxites are particularly low in iron, titanium, and silica, and are used in the preparation of alumina from which aluminium is made.

A few characteristics, which indicate in a general way the quality of bauxite, may be mentioned, though it is recognized that none of them are dependable. In general, bauxite of fair grade will not show the marks of a hammer when it is hit a glancing blow, though some bauxite has been shipped which can be cut with the hammer.

Good bauxite, which has been dried either in the open or in kilns, when thrown on a hard floor has a distinct rattle which bauxitic clay does not have. The pisolites of the lighter-colored bauxites of the central-Georgia field have a peculiar brownish-buff color and look something like horn or flint; they ordinarily can not be broken or marked with the finger nail in bauxites of good grade.

Some measure of the relative quality of dried bauxite can be had by grinding a sample in an agate mortar for half a minute. A bauxite of good grade will be found hard to grind and will stick to the mortar with such tenacity that it will have to be scoured out; a poor bauxite or bauxite clay will grind much more easily and will stick very little, if at all; and clay or kaolin grinds with ease and does not stick to the mortar. Similar results are found if the sample is rubbed on glass and the glass will not be scratched by even high-grade bauxite.

## UNITED STATES DEPOSITS.

*Arkansas field.*—The Arkansas deposits are closely associated with syenitic igneous rocks which outcrop in Saline and Pulaski counties. A large part of the bauxite, according to Mead,[1] is clearly the result of surface alteration of the syenite in place, though some deposits of transported and reconcentrated bauxites are found in the sedimentary rocks around the syenite center. The syenite first alters to kaolin, which on further action of the surface waters loses silica and changes to bauxite of the "granitic" type, in which the original texture of the syenite is preserved. Further action similar to concretionary growth results in the formation of the usual pisolitic variety of bauxite.

The deposits in Pulaski and Saline counties have been extensively worked by the American Bauxite Co., the Republic Mining & Manufacturing Co., the National Bauxite Co., and the Globe Bauxite Co. Recently the American Bauxite Co. has built a loading station at Bauxippi, Ark., to transship bauxite from cars to river boats for transportation to its plant at East St. Louis.

*North Georgia-Alabama-Tennessee field.*—In Cherokee County, northeastern Alabama, near Rock Run and Piedmont; in Floyd County, northwestern Georgia, near Rome and Cave Springs; and also near Chattanooga and Keensburg, Tenn., there are large pocket deposits of bauxite which have been worked for a number of years. Some of the pockets have been worked out; others are still in operation; and new deposits are still being found.

The pockets are generally lenticular, ranging from 25 to 300 feet in greatest horizontal dimensions and varying in depth, though the depth is usually comparable to the larger horizontal axis. The pockets are disposed along fault lines, which are clearly marked. Most of them are at the base of grayish quartzite ridges and at the edge of the red clay areas that have resulted from the weathering of the Knox dolomite. The presence of bauxite is usually indicated on the surface by "dornicks" or rounded bowlders of pisolitic bauxite, which are often uncovered in the cultivation of fields.

[1] Mead, W. J., The occurrence and origin of the bauxite deposits of Arkansas: Econ. Geology, vol. 10, No. 1, pp. 28–54, 1915.

Not all of the material in the pockets is bauxite, as irregular masses of red and white kaolin are found mixed with the bauxite; but these materials can be separated in mining, as the ore is usually distinctly pisolitic and harder than the kaolin. In some deposits the pisolites are harder than the matrix of the bauxite, and the reverse conditions hold in other places.

All the bauxite mined by the Republic Mining & Manufacturing Co. is kiln-dried before shipment, but none of the other operators dry their ore. Mining at all properties is by hand methods and a number of the properties have no power-driven equipment, though several of the larger pits are equipped with steam pumps and engines for operating the incline plain hoists. A little powder is used to loosen the hard bauxite for ease in picking.

The deposits near Piedmont, Ala., have not been worked for a few years; but the National Bauxite Co. is reported to be reopening the Snider pit about 7 miles north of that place. Near Rock Run, Ala., the Republic Mining & Manufacturing Co. is working several deposits; the largest about 1½ miles east of the town is a pocket about 300 feet in diameter, which is still producing at a depth of 92 feet.

It is reported that bauxite deposits near Fort Payne, Dekalb County, Ala., will be on a producing basis in the near future.

Deposits near Cave Springs, Ga., are under development by the Republic Mining & Manufacturing Co. and Asbury & Sparks, and the first-named company is also shipping from the Booger-Hollow pit near Six Mile.

In the Hermitage area north of Rome, Ga., the Republic Mining & Manufacturing Co. is shipping from a number of deposits on the east side of Armstrong Mountain, near Hermitage, and Asbury & Sparks are developing a pocket about 2½ miles south-southeast of Pinson station.

The bauxite deposits on Missionary Ridge, near Chattanooga, Tenn., were not extensively worked during 1916, though a small output was made. The Carter County deposits in northeastern Tennessee were under development throughout the year. The deposits at both places are quite similar to those near Rome and Cave Springs.

*Central Georgia field.*[1]—The first discovery of bauxite in central Georgia was made in Wilkinson County, and for a time the chief bauxite production of the field was made from deposits near McIntyre and Toomsboro. This area has been gradually extended so that at present bauxite is known to occur westward nearly to Dry Branch, northward to Stephens Potters, southward to Irwinton, and eastward to Oconee River. Deposits near Gordon, McIntyre, Toomsboro, and Irwinton are now under development.

These flat-lying lenticular deposits are at all places associated with nearly white sedimentary kaolins of Upper Cretaceous age. In most places the bauxite lies above the kaolin and the base of the bauxite is not distinct, as it grades into unaltered kaolin. At a few places kaolin overlies a bed of bauxite, into which it grades. Whether the bauxite was deposited as such or is an alteration of the kaolin of recent occurrence is a moot question, but the evidence seems to favor

[1] Shearer, H. K., A report on the bauxite and fuller's earth of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 31, pp. 19–140, 1917.

the hypothesis that the bauxite was formed by alteration of the kaolin subsequent to its deposition. The principal operators in this field are the Republic Mining & Manufacturing Co., National Bauxite Co., General Bauxite Co., and the Columbia Kaolin & Aluminum Co.

Since the first bauxite deposits were found in central Georgia, a large field has been opened near Andersonville, in Sumter County, and within the last two years promising deposits have been found in the adjoining parts of Macon and Schley counties. The deposits in this area are similar to those in Wilkinson County in distribution and character, but are found in younger kaolins. These kaolins are Tertiary and probably of the Midway or Claiborne (Eocene) age. The chief operators are the Republic Mining & Manufacturing Co., Kalbfleisch Corporation, Easterlin, and Maynard & Simmons.

Within the last year developments seem to point to a westward extension of the bauxite deposits into Randolph and Stewart counties in western Georgia and possibly into eastern Alabama on a line with known occurrences in adjacent parts of Georgia.

An unusual deposit of bauxite, about 2 miles west of Warm Springs or Bullochville, in Meriwether County, has been worked for a few years. At this place beds of kaolin, which dip steeply north, are exposed by the workings. Two of the beds have been altered to bauxite, one a light-colored variety of good grade from which shipments have been made, the other a dark-red variety which has not been mined. The deposit was operated by the Republic Mining & Manufacturing Co.

## ALUMINUM.

### DOMESTIC PRODUCTION AND CONSUMPTION.

The value of primary aluminum produced in the United States in 1916 was $33,900,000, an increase of 108 per cent over the value of the output in 1915. This increase is, in part, due to the increased price, but is also due in a considerable degree to the greater output of primary aluminum in 1916 than in 1915. It will also be noticed, as shown in the following table, that the value of aluminum produced from scrap in the United States in 1916 increased more than 300 per cent over the value of the production in 1915, owing in part to the greatly increased price in the open market, but also to greater recoveries of aluminum from scrap. The value of the total domestic production of new metal and metal produced from scrap in 1916 was $57,330,200, as compared with $22,082,100 in 1915. The value of imports of aluminum has continued to decline, but the value of exports has increased greatly.

The sales of aluminum in 1916, as reported by Metal Industry,[1] are given below.

The Aluminum Co. of America, Pittsburgh, Pa., announces that it did a gross business of $25,940,427 in 1916 from the sale of 86,589,774 pounds of aluminum at an average price of 29.96 cents a pound. In addition, the company supplied to its subsidiary, the United States Aluminum, 24,821,061 pounds of aluminum, which was fabricated by the latter concern.

These figures are somewhat lower than those published by the Geological Survey. The discrepancy may be in part explained by stocks held by the company and in part by differences in price.

[1] The Aluminum Co. of America: Metal Industry, vol. 15, No. 7, p. 327, 1917.

*Value of aluminum produced and consumed in the United States, 1912–1916.*

| Year. | Domestic production. | | Imports.[b] | Exports.[c] | Apparent consumption. |
|---|---|---|---|---|---|
| | Primary metal. | Secondary metal.[a] | | | |
| 1912 | $7,400,000 | (d) | $3,541,591 | $1,347,621 | $9,593,970 |
| 1913 | 9,450,000 | $2,199,480 | 3,845,611 | 966,094 | 14,528,997 |
| 1914 | 10,080,000 | 1,673,140 | 2,801,211 | 1,546,510 | 13,007,841 |
| 1915 | 16,280,000 | 5,802,100 | 1,808,193 | 3,682,117 | 20,208,176 |
| 1916 | 33,900,000 | 23,430,200 | 1,785,870 | 15,417,134 | 43,698,936 |

[a] Value based on average open market price, as quoted by Eng. and Min. Jour.
[b] Imports for consumption, figures from Department of Commerce reports. Includes aluminum in crude form, leaf, sheets, plates, bars, strips, wire, rods, and all manufactures of; table, kitchen, and hospital ware.
[c] Exports of aluminum and manufactures of; figures from Department of Commerce reports.
[d] No statistics available.

The value of the aluminum consumed in the United States in 1916 was $43,698,936, an increase of nearly 117 per cent over the value of the consumption in 1915.

## MARKET AND PRICES OF ALUMINUM.

In the United States the quoted prices for primary or "virgin" aluminum[1] ranged from a low of 55 cents a pound in January to a high of 65.12 cents a pound in November, the average for the year being 60.71 cents a pound, as compared with 33.98 cents in 1915. These prices are for small lots and immediate delivery, offered in the open market, and must not be taken to represent the price received by the single producer of primary aluminum in this country. It is reported,[1] apparently on good authority, that the contract prices of the Aluminum Co. of America to regular consumers ranged from 31 to 37 cents a pound in 1916, as compared with 20 to 31 cents a pound in 1915. The demand for aluminum was very large during 1916, particularly for war materials of various sorts, and it is highly probable that the demands in the near future will be increased considerably.

*Prices of aluminum, 1912–1916, in cents per pound.*[a]

| Year. | Average open market price, small lots. | Contract price. |
|---|---|---|
| 1912 | 22.01 | 20–21 |
| 1913 | 23.64 | (b) |
| 1914 | 18.63 | (b) |
| 1915 | 33.98 | 20–31 |
| 1916 | 60.71 | 31–37 |

[a] Eng. and Min. Jour. quotations in annual review numbers.
[b] No figures published, but it seems reasonable to believe that contracts were made on approximately the same basis as for 1912.

## NOTES ON THE ALUMINUM INDUSTRY.

The Aluminum Co. of America is now operating four electrolytic plants in the United States at which aluminum is made; they are located at Massena and Niagara Falls, N. Y., Maryville, Tenn., and

[1] Eng. and Min. Jour., vol. 103, p. 29; also Metal Industry, vol. 15, p. 11, 1917.

Badin, N. C. The Badin plant made its initial run in 1916 and is expected to be in full operation in 1917. This plant, construction of which was begun by French capital, was taken over by the American company in 1915 and pushed to completion. It is estimated that its capacity, when in full operation, will be approximately 22,000 short tons of metal a year.

A plant, presumably to handle the Guiana bauxite which the Aluminum Co. of America expects to bring to this country, is reported to be under construction at Sollers Point, near Baltimore, Md.

As showing the aluminum-producing capacity of the countries of the world, the following figures, taken from various sources,[1] are of interest for comparison, though they are not given as accurate figures of plant capacity:

*Estimated capacity of aluminum plants of the world.*

| | Short tons. | | Short tons. |
|---|---|---|---|
| United States and Canada[2] | 87,500 | England | 12,000 |
| France | 20,000 | Italy | 7,000 |
| Switzerland | 20,000 | Japan[2] | 250 |
| Norway[2] | 16,000 | | |
| | | | 162,750 |

Some information concerning the French aluminum industry as late as 1912 has been published by Mailloux.[3]

## USES OF ALUMINUM.

No new uses of aluminum of importance were reported during 1916. Apparently the use of aluminum powder in the high explosive "ammonal" greatly increased, though there was a tendency to a restriction of the use of this form of aluminum for precipitation of silver from cyanide solution in metallurgic practice. Aluminum foil has not entirely replaced tin and lead foil for the various uses to which those materials are put.

A large part of the domestic consumption of aluminum is in the form of castings and drawn and pressed ware, which enter into almost every industry. The more important consumption, at present, appears to be in airplanes, automobiles, and war munitions, though immense quantities of cast and pressed aluminum utensils for war, household, and industrial uses are consumed.

Aluminum wire for the transmission of electricity has been replaced by copper to a considerable extent, apparently not so much because of failure of aluminum as because of the high price of the metal as compared with copper.

Patents for many inventions relating to aluminum—various alloys, methods of fabrication, soldering, and purification of scrap aluminum—have been issued during the last year, copies of which may be obtained from the United States Patent Office.

[1] Present position of the aluminum industry: Min. Jour. (London), vol. 116, pp. 92, 93, Feb. 17, 1917; also Commerce Repts., Mar. 9, 1916; Eng. and Min. Jour., Sept. 2, 1916; and Metal Industry, vol. 15, p. 327, July, 1917.

[2] Includes plants not in operation.

[3] Mailloux, C. O., Hydroelectric power and electrochemistry and electrometallurgy in France: Met. and Chem. Eng., vol. 16, pp. 265–273, 321–325, 1917.

## SECONDARY ALUMINUM.

Large quantities of aluminum are consumed each year that are not new metal but are derived from remelted scrap and alloys. It has long been recognized that the losses in remelting scrap containing aluminum were large. The Bureau of Mines has recently issued a comprehensive report on this subject[1] dealing not only with existing methods in use by various melters but also going into the literature and theory of the subject. A number of suggestions for melting various classes of scrap aluminum are given.

More detailed information concerning secondary aluminum derived from scrap metal, sweepings, skimmings, and drosses will be found in the Survey report on secondary metals, by J. P. Dunlop, published as a chapter of Part I, Mineral Resources of the United States.

## OTHER BAUXITE PRODUCTS.

Nearly 70 per cent of the domestic output of bauxite in 1916 went into aluminum, but manufacturers of aluminum salts used nearly 19 per cent; apparently 8 per cent was consumed in the manufacture of bauxite abrasives; and 3 per cent was used by makers of "high-alumina refractories," sometimes called bauxite brick.

Within the last two years many foreign and domestic patents have been issued relating to the use of bauxite in the fixation of nitrogen, the manufacture of aluminum salts, and the fabrication of abrasives and refractories. Copies of these patents may be obtained from the United States Patent Office, Washington, D. C.

## ALUMINUM SALTS.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulphate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum and no figures of domestic production are available. Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1916 being 27,257 short tons, valued at $1,177,881, an increase over 1915 of approximately 10 per cent in quantity and of 68 per cent in value.

Aluminum sulphate is made at 18 plants, 6 of which are located at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum sulphate produced in the United States in 1916 was 153,860 short tons, of which 6,037 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulphate which entered the market, 147,823 short tons, was less than the quantity in 1915 by 12 per cent, and the total domestic production fell off about 9 per cent. The value of the total production of aluminum sulphate in 1916 was $4,410,741, an increase of nearly 37 per cent over the value of the greater production of 1915.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at 5 plants in 1916, the total output reported to the Geological Survey

[1] Gillett, H. W., and James, G. M., Melting aluminum chips: Bur. Mines Bull. 108, 1916.

being 3,322 short tons, valued at $234,423, or approximately $70 a short ton. This is the first time statistics of production of aluminum chloride have been collected by the Geological Survey and the figures are not included in the following table:

*Alum and aluminum sulphate produced in the United States and aluminum salts imported, 1912–1916.*

| Year. | Production. | | | | | | Imports.[a] | |
|---|---|---|---|---|---|---|---|---|
| | Alum. | | | Aluminum sulphate. | | | Quantity (short tons). | Value. |
| | Quantity (short tons). | Value. | Price per ton. | Quantity (short tons). | Value. | Price per ton. | | |
| 1912..... | 9,246 | $293,995 | $31.80 | 150,427 | $2,909,495 | $19.34 | 3,342 | $84,606 |
| 1913..... | 9,605 | 312,822 | 32.57 | 157,749 | 2,977,708 | 18.88 | 2,702 | 66,549 |
| 1914..... | 18,238 | 565,989 | 31.03 | 164,954 | 2,942,572 | 17.84 | 2,891 | 73,028 |
| 1915..... | 24,915 | 699,256 | 28.07 | 169,153 | 3,224,495 | 19.06 | 1,408 | 34,320 |
| 1916..... | 27,257 | 1,177,881 | 43.21 | 153,860 | 4,410,741 | 28.67 | 1,247 | 68,660 |

[a] Includes alumina, aluminum hydrate or refined bauxite, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground.

## BAUXITE ABRASIVES.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, exolon, and lionite, are made by fusing bauxite in an electric furnace. The fused product is broken, sized, and put into shape for market. Some grades of nearly white artificial aluminum abrasives are believed to be made from alumina. These products are sold in the form of powders, cloth, grinding stones, and wheels of various shapes for a multitude of uses.

The total production of artificial abrasives made from bauxite in 1916 was 30,708 short tons, valued at $2,139,230. Statistics of these products have not been published separately heretofore by the Geological Survey.

## HIGH-ALUMINA REFRACTORIES.

There are two classes of high-alumina refractories now on the market. One commonly called bauxite brick is made by mixing various proportions of calcined bauxite or high-alumina clay with a bonding material such as fire clay, sodium silicate, or lime. The material is shaped and then burned at a high temperature in down draft kilns. Refractories of this character are being made by Laclede Christy Clay Products Co., Harbison Walker Refractories Co., Charles Taylor & Sons, and the Massillon Stone & Fire Brick Co. Not all the refractories made by these companies are sold as bauxite brick, and in fact some do not contain bauxite. It would appear that any refractory brick containing 58 per cent or more of alumina should be included in a statement of the production of high-alumina refractories.

From the best information available to the Geological Survey it would appear that in 1916 bauxite refractories containing 58 per cent or more of alumina to the amount of over 1,000,000 brick, 2½ by 4½ by 9 inches in size, were sold. As has been stated, the refractories are

not all sold as brick, but the total quantity is reduced to a comparable figure for publication. The price of these refractories varied from $175 to $380 a thousand, the price apparently depending on the quality of the product.

Refractory brick containing from 45 to 58 per cent alumina were sold in large quantities, the output in 1916 being probably 2,000,000 brick, at prices ranging from $50 upward a thousand.

The second class of high-alumina refractories consists of those made by the electric fusing of bauxite, the molten mass being cast in desired shapes. No information is available concerning the production of this class of refractory, which is being made by some of the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns.

# GOLD, SILVER, COPPER, AND LEAD IN ALASKA.

(MINES REPORT.)

By ALFRED H. BROOKS.

## INTRODUCTION.[1]

The Alaskan mining industry was remarkably prosperous in 1916, as is indicated by a total mineral output, including metals and nonmetals, valued at nearly $50,000,000. Of this large sum the gold, silver, copper, and lead were valued at $47,746,659, as compared with $32,425,784 in 1915. The great increase in the quantity and value of these four metals from Alaskan mines, amounting to $15,320,875, or about 47 per cent, is due largely to the increased quantity and high price of copper, though the production of gold, silver, and lead in 1916 also showed a substantial increase over that of 1915.

It is not expected that Alaska will continue to produce so much mineral wealth each year, yet the extensive preparations made in 1916 for lode and placer mining and the development of the coal-mining industry, now assured, promise a continuous healthy growth in the mining industry of the Territory. This is especially true of the Pacific coast region and of the districts served by railroads built or under construction.

The beginning of Alaska's great mining industry was made in 1880, when about $20,000 worth of gold was taken from the Juneau placers. During 37 years of mining the value of the annual mineral output has grown to nearly $50,000,000. This growth has not been uniform, especially since 1898, when the yield of gold from the placers became a large factor in the value of the total annual mineral output. For many years the fluctuation in total annual value was a reflection of the condition of the placer-mining industry. Since 1910 the variation in the value of the copper output has also been an important element in determining the curve of mineral production. Silver and lead alone are not mined in Alaska, but some silver and lead have always been recovered incidentally to the mining of gold.

Though it is generally assumed that the annual gold output of the Territory has been derived largely from placer mines, this is not entirely true. From the time that lode mining began, in 1883, until the discovery of the rich placers of Nome, in 1898, the value of the output

[1] The data on mining conditions and production here given are abstracted from a paper by Alfred H. Brooks, published in United States Geological Survey Bulletin 662. Mr. Brooks was assisted in the statistical work by E. M. Aten. The original paper and the papers that accompany it treat the subject at greater length than is desired here and should be consulted by those who require the more detailed information. Some of the figures here given are revisions of those in the original paper.

of gold from the lodes was greater than that from the placers. Throughout this period the total annual gold production of Alaska was steadied by the output of the great Treadwell group of mines. It is for this reason that the curve of mineral production shows but few fluctuations during the first 17 years of mining.

With the discovery of the Nome gold field in 1898 the Alaskan mining industry passed into a second phase of its evolution. In this epoch the output of the placers, which fluctuated greatly from year to year, played a dominating part in the value of the annual production. The first peak in mineral production was reached in 1900, and was due to the gold from Seward Peninsula. A second was reached in 1906, when a large production from the Fairbanks placer mines was added to that of Seward Peninsula. Had it not been for the rapid successive discovery of such camps as Nome, Fairbanks, Iditarod, Hot Springs, Ruby, and others, the gold output would not have been maintained. The development of a new camp about the time of the decline of the output from an older camp prevented much greater fluctuations in the annual production than actually took place. This period was an era both of wasteful mining and of excessive speculation.

From this epoch of bonanza placer mining Alaska is gradually emerging, the first step being the installation of large dredges on Seward Peninsula, which began in 1905. Since then many others have been installed on the peninsula, and dredge mining is becoming an important industry in other parts of the Territory. There has also been a general improvement in placer-mining methods in all of the older placer districts and a more stable annual production. As a result, Alaska's annual placer-gold production has shown comparatively little variation during the last four years. The maintenance of a large annual output of placer gold seems assured, though it does not necessarily follow that the minimum output has been reached. There is still a large percentage of gold won from bonanza deposits which have no great area. Until the placer production of gold is derived largely from the exploitation of extensive deposits on a large scale, fluctuations in the annual output are to be expected.

The price of copper not only acts directly in determining the value of the copper actually produced, but also indirectly increases the value, because when copper is high a number of mines are operated that are idle during periods of low price. The abnormally high price of copper during the last two years accounts in a measure for the great increase in production of copper, as well as for the increase in total mineral production. This increase in value is abnormal and can not be taken as a measure of future value, yet there is every assurance that Alaska will continue to produce a large annual output of copper, even under normal market conditions.

## PRODUCTION.

The following tables give an estimate of the total production of gold, silver, copper, and lead since the beginning of mining in 1880. For the earlier years, especially for silver, the figures are probably far from being correct, but they are based on the best information now available.

*Gold, silver, copper, and lead produced in Alaska, 1880–1916.*

| Year. | Gold. | Silver. | | Copper. | | Lead. | |
|---|---|---|---|---|---|---|---|
| | | Quantity (fine ounces). | Commercial value. | Quantity (pounds). | Value. | Quantity (short tons). | Value. |
| 1880 | $20,000 | | | 3,933 | $826 | | |
| 1881 | 40,000 | | | | | | |
| 1882 | 150,000 | | | | | | |
| 1883 | 301,000 | | | | | | |
| 1884 | 201,000 | 10,320 | $11,146 | | | | |
| 1885 | 300,000 | | | | | | |
| 1886 | 446,000 | | | | | | |
| 1887 | 675,000 | | | | | | |
| 1888 | 850,000 | 2,320 | 2,181 | | | | |
| 1889 | 900,000 | 8,000 | 7,490 | | | | |
| 1890 | 762,000 | 7,500 | 6,071 | | | | |
| 1891 | 900,000 | 8,000 | 7,920 | | | | |
| 1892 | 1,080,000 | 8,000 | 7,000 | | | | |
| 1893 | 1,038,000 | 8,400 | 6,570 | | | | |
| 1894 | 1,282,000 | 22,261 | 14,257 | | | | |
| 1895 | 2,328,500 | 67,200 | 44,222 | | | | |
| 1896 | 2,861,000 | 145,300 | 99,087 | | | | |
| 1897 | 2,439,500 | 116,400 | 70,741 | | | | |
| 1898 | 2,517,000 | 92,400 | 54,575 | | | | |
| 1899 | 5,602,000 | 140,100 | 84,276 | | | | |
| 1900 | 8,166,000 | 73,300 | 45,494 | | | | |
| 1901 | 6,932,700 | 47,900 | 28,598 | 250,000 | 40,000 | | |
| 1902 | 8,283,400 | 92,000 | 48,590 | 360,000 | 41,400 | 796 | 67,142 |
| 1903 | 8,683,600 | 143,600 | 77,843 | 1,200,000 | 156,000 | | |
| 1904 | 9,160,000 | 198.700 | 114,934 | 2,043,586 | 275,676 | | |
| 1905 | 15,630,000 | 132,174 | 80,165 | 4,805,236 | 749,617 | | |
| 1906 | 22,036,794 | 203,500 | 136,345 | 5,871,811 | 1,133,260 | | |
| 1907 | 19,349,743 | 149,784 | 98,857 | 6,308,786 | 1,261,757 | | |
| 1908 | 19,292,818 | 135,672 | 71,906 | 4,585,362 | 605,267 | | |
| 1909 | 20,411,716 | 147,950 | 76,934 | 4,124,705 | 536,211 | | |
| 1910 | 16,126,749 | 157,850 | 85,239 | 4,241,689 | 538,695 | | |
| 1911 | 16,853,256 | 460,231 | 243,923 | 27,267,878 | 3,408,485 | | |
| 1912 | 17,145,951 | 515,186 | 316,839 | 29,230,491 | 4,823,031 | | |
| 1913 | 15,626,813 | 362,563 | 218,988 | 21,659,958 | 3,357,293 | | |
| 1914 | 15,764,259 | 394,805 | 218,327 | 21,450,628 | 2,852,934 | 28 | 1,344 |
| 1915 | 16,702,144 | 1,071,782 | 543,393 | 86,509,312 | 15,139,129 | 437 | 41,118 |
| 1916 | 17,241,713 | 1,379,171 | 907,495 | 119,854,839 | 29,484,291 | 820 | 113,160 |
| | 278,100,656 | 6,302,459 | 3,729,406 | 339,768,214 | 64,403,872 | 2,081 | 222,764 |

*Mine production of gold, silver, copper, and lead in Alaska, 1915–16.*

| Year. | Gold. | | Silver. | | Copper. | | Lead. | | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. | Quantity (pounds). | Value. | Quantity (short tons). | Value. | |
| 1915 | 807,966 | $16,702,144 | 1,071,782 | $543,393 | 86,509,312 | $15,139,129 | 437 | $41,118 | $32,425,784 |
| 1916 | 834,068 | 17,241,713 | 1,379,171 | 907,495 | 119,854,839 | 29,484,291 | 820 | 113,160 | 47,746,659 |
| Increase | 26,102 | 539,569 | 307,389 | 364,102 | 33,345,527 | 14,345,162 | 383 | 72,042 | 15,320,875 |

The following table gives an estimate, based on the best available data, of the source of the gold and silver produced in Alaska since mining began in 1880. About $65,100,000 in gold, or nearly one-third of the total estimated output, was produced before 1905, and there is but scant information about its source. For the period since that time fairly complete statistical returns are available, and it is probable that the figures presented in the table are near enough the truth to be valuable. The figures given for the silver recovered

from placer gold and from siliceous ores are probably less accurate than those for the gold. Copper mining did not begin in Alaska until 1901, and the figures for gold and silver derived from this industry, as now presented, are therefore a close approximation to the actual output.

*Source of the gold and silver produced in Alaska, 1880–1916.*

| | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| Siliceous ores | 3,844,405 | $79,470,900 | 1,096,238 | $731,256 |
| Copper ores | 62,730 | 1,296,764 | 3,567,308 | 2,089,518 |
| Placers | 9,545,983 | 197,332,992 | 1,638,913 | 908,631 |
| | 13,453,118 | 278,100,656 | 6,302,459 | 3,729,406 |

This table shows that about 28 per cent of the total gold production of Alaska has been obtained from the auriferous lode mines (siliceous ores). In 1916 the lode-gold production was 38 per cent of the total annual output in gold; in 1915, 38 per cent; in 1914, 32 per cent; in 1913, 31.6 per cent; and in 1912, 29 per cent. In the following table the production of precious metals has been distributed as to sources.

*Source of gold, silver, copper, and lead produced in Alaska in 1916.*

| | Total quantity (short tons). | Gold. | | Silver. | | Copper. | | Lead. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. | Quantity (pounds). | Value. | Quantity (short tons). | Value. |
| Siliceous ores | 3,548,798 | 286,028.60 | $5,912,736 | 110,050 | $72,413 | | | 820 | $113,160 |
| Copper ores | 617,264 | 9,141.76 | 188,977 | 1,207,121 | 794,286 | 119,854,839 | $29,484,291 | | |
| Placers | | 538,897.50 | 11,140,000 | 62,000 | 40,796 | | | | |
| | 4,166,062 | 834,067.86 | 17,241,713 | 1,379,171 | 907,495 | 119,854,839 | 29,484,291 | 820 | 113,160 |

*Copper.*—The enormous copper output from Alaskan mines in 1916 amounted to 119,854,839 pounds, valued at $29,484,291. In 1916, 18 copper mines were operated, compared with 13 in 1915—9 in the Ketchikan district, 6 in the Prince William Sound district, and 3 in the Chitina district. The output from the Kennecott and Jumbo mines, in the Chitina district, overshadowed all other operations. Had the transportation companies and smelters been able to handle the ore many of the smaller copper mines on the coast would have made a much greater output. The average copper content of the ore mined was 9.7 per cent, and the value of gold and silver recovered about $1.59 a ton. The average for 1915 was 11.7 per cent copper and $1.65 a ton in gold and silver.

*Lode mining.*—Twenty-nine lode gold mines, large and small, were operated in 1916—1 less than in 1915. The value of the output of gold from siliceous ores decreased from $6,069,023 in 1915 to

$5,912,736 in 1916. Southeastern Alaska, especially the Juneau district, is still the center of large quartz-mining developments in the Territory. Next in importance is the Willow Creek district. There was also considerable lode mining on Prince William Sound, but a very decided decrease in the Fairbanks district. Owners of deep mines at Fairbanks are awaiting the lowering in operating costs, especially in fuel, which will be brought about by the Government railroad. Of the producing mines 8 were in southeastern Alaska, 5 on Prince William Sound, 4 on Kenai Peninsula, 4 in the Willow Creek district, and 8 in the Fairbanks district. In 1916 the average value of the gold and silver contents of all siliceous ores milled was $1.70 a ton; the average for 1915 was $2.79 a ton. These average values show the dominance of the large quantity of low-grade ores treated in the Juneau district.

*Placer mining.*—The value of the placer gold produced in 1916 was about $11,140,000; in 1915 it was $10,480,000. In 1916 each of the older placer districts, except Fairbanks, maintained or increased its gold output, compared with that of the preceding year. The increased output is, however, to be credited chiefly to the newly developed Marshall and Tolovana districts. It is estimated that about 650 placer mines were operated in the summer of 1916 and 215 during the previous winter, but many of them for only a part of the season. The only new placer-bearing area discovered during 1916 was in the Tolstoi Creek basin, in the southern part of the Innoko district, where a little productive mining was done. There were, however, notable developments of gold placers in the Marshall and Tolovana districts and in the Dime Creek region of the southeastern part of Seward Peninsula.

The following table shows approximately the total bulk of gravel mined annually and the value of the gold recovered per cubic yard. The table is based in part on returns made by placer-mine operators and in part on certain assumptions which do not now admit of proof but which are supported by a large number of facts. Therefore, although the table is only approximately correct, it indicates the magnitude of the true figures.

*Estimated quantity of gravel sluiced in Alaska placer mines and value of gold recovered, 1908–1916.*

| Year. | Total quantity of gravel (cubic yards). | Value of gold recovered per cubic yard. | Year. | Total quantity of gravel (cubic yards). | Value of gold recovered per cubic yard. |
|---|---|---|---|---|---|
| 1908 | 4,275,000 | $3.74 | 1913 | 6,800,000 | $1.57 |
| 1909 | 4,418,000 | 3.66 | 1914 | 8,500,000 | 1.26 |
| 1910 | 4,036,000 | 2.97 | 1915 | 8,100,000 | 1.29 |
| 1911 | 5,790,000 | 2.17 | 1916 | 7,100,000 | 1.57 |
| 1912 | 7,050,000 | 1.70 | | | |

This table shows that during the last nine years there has been a large decline in the average gold content of the gravels mined. This is a result of the improved methods of placer mining that are being introduced, especially in the use of dredges. If data were available

on the average recovery of gold prior to 1908, a far greater decline would be shown. The higher average recovery in 1916 compared with that of 1915 was largely because the Alaskan dredges were for the most part working on far richer placer ground and because a larger percentage of the placer gold came from the rich deposits of newer districts, such as Hot Springs, Tolovana, and Koyukuk. In these districts recoveries of $7 to $20 in gold a cubic yard are not uncommon. In the final analysis the movement of the miners toward the richer placers, made evident by the average recoveries for 1915 and 1916, is the result of the present economic conditions, which, as will be shown below, affect gold mining more adversely than any other industry.

Thirty-four gold dredges were operated in Alaska in 1916, one less than in 1915. Four dredges were built during the year. Twenty-seven dredges were operated in Seward Peninsula, 3 in the Iditarod and 1 each in the Ruby, Fairbanks, Circle, and Yentna districts. These dredges produced about $2,679,000 in gold and handled about 3,900,000 cubic yards of gravel. In 1915 the 35 dredges handled about 4,600,000 cubic yards of gravel and made a recovery of gold valued at $2,330,000. The average gold recovery per cubic yard was about 69 cents in 1916 and 51 cents in 1915. The gold dredges of Seward Peninsula made an average recovery of 53 cents a cubic yard in 1916 and of 35 cents in 1915. The dredges of the Alaska Yukon districts are working on placers of relatively high gold tenor. The value of gold recovery per cubic yard in 1916 was about 85 cents; in 1915, about 80 cents.

These statements do not encourage the hope of an immediate expansion of the gold-dredging industry of Alaska. During the last three years there has been a decrease in the number of dredges operated, and the gold output from this source has been maintained by the production of a few machines working on relatively rich placers. Dredging companies in Seward Peninsula which have in the past mined gravels of lower gold tenor have in part ceased operation, and there is now a general tendency throughout Alaska to limit the installation of dredges to relatively rich placers. This is no doubt owing in large part to present economic conditions, for the value of the product does not vary, though the cost of operation is increased by high prices.

There are in Alaska many placers rich enough to be dredged under present adverse conditions, and the exploitation of these placers will continue more extensively than in the past. The best base for a permanent dredging industry, however, is in the mining of the large bodies of auriferous gravels, the tenor of which is too low to attract operators under present conditions.

Though dredges were built for use in the Alaska Yukon as early as 1898 and at Nome in 1900, this method of placer mining was not profitable until 1903, when two small dredges were successfully operated in Seward Peninsula. Dredging began in the Fortymile district in 1907, in the Iditarod, Birch Creek, and Fairbanks districts in 1912; and in the Yentna district in 1916. To the end of 1916 gold valued at about $15,110,000 has been recovered by dredges. The distribution of this output by years is shown in the following table:

*Estimate of gold produced from dredge mining in Alaska, 1903–1916.*

| Year. | Number of dredges operated. | Value of gold output. | Year. | Number of dredges operated. | Value of gold output. |
|---|---|---|---|---|---|
| 1903 | 2 | $20,000 | 1911 | 27 | $1,500,000 |
| 1904 | 3 | 25,000 | 1912 | 38 | 2,200,000 |
| 1905 | 3 | 40,000 | 1913 | 36 | 2,200,000 |
| 1906 | 3 | 120,000 | 1914 | 42 | 2,350,000 |
| 1907 | 4 | 250,000 | 1915 | 35 | 2,330,000 |
| 1908 | 4 | 170,901 | 1916 | 34 | 2,679,000 |
| 1909 | 14 | 424,993 | | | |
| 1910 | 18 | 800,000 | | | 15,109,894 |

*Lead.*—Though silver-lead ores are found in many parts of Alaska, no deposits have yet been opened on a commercial basis. The production of lead is therefore only incidental to the mining of ores chiefly valuable for other metals. Some test shipments of galena ore were made from several deposits in 1916, and these, with the much larger recovery of lead from gold ores, made a total output of 820 tons of lead, valued at $113,160, compared with a production in 1915 of 437 tons, valued at $41,118.

The estimated total quantity of the lead derived from ore and concentrates shipped from Alaska for the period 1892–1917 is 2,081 short tons, valued at $222,764.

## REVIEW BY REGIONS.[1]

### SOUTHERN ALASKA.

#### LODE MINING.

Eight gold-lode mines and 9 copper mines were operated in southeastern Alaska in 1916.

The value of the mineral production from these mines was gold, $5,524,940; copper (3,526,700 pounds), $867,569; silver, $83,690; and lead, $113,160.

As in the past, much the largest mining operations were in the Juneau district. All the productive copper mines of southeastern Alaska were in the Ketchikan district in 1916. The Chichagof gold mine was the only productive property in the Sitka district.

#### PLACER MINING.

*Porcupine district.*—The three placer mines of the Porcupine district were operated in 1916.

*Yakataga Beach.*—Gold placer mining continued on the beach in the Yakataga district in 1916.

*Lituya Bay.*—It is reported that a number of placer miners worked on the beaches of Lituya Bay and that gold-bearing gravels were found in the streams tributary to Lituya Bay. It appears to be almost definitely established that some of the beach sands carry a little platinum.

[1] This review is a summary of the most important facts that are presented in more detail in Survey Bulletin 662.

### PRINCE WILLIAM SOUND.

The value of the total mineral production of Prince William Sound in 1916 was $2,975,263, compared with $1,340,996 in 1915. Eight copper mines and 10 gold mines were operated during the year. The Beatson-Bonanza, Ellamar, and Midas mines were the largest producers of copper, and the Granite, Ellamar, and Ramsay-Rutherford mines the largest producers of gold.

### COPPER RIVER REGION.

Mining in the Copper River region in 1916 included the development of copper mines in Chitina Valley and of placer mines in the Nizina and the Chistochina districts. The copper production of this region was much larger than in 1915. Three mines, the Kennecott-Bonanza, the Kennecott-Jumbo, and the Mother Lode, were operated on a productive basis throughout the year, although the shipments from the Mother Lode were made only in winter and were small compared with those from the Bonanza and the Jumbo. Development work was done on a number of other copper properties in the district and a few carloads of ore were produced.

About 30 placer mines were operated in the Copper River basin and produced gold valued at $290,000. The principal operations were on Dan, Chititu, and Rex creeks, and the gold was recovered by hydraulic methods.

Two hydraulic plants, one of which was installed in 1916, were in operation in the Chistochina district. The largest operations were on Slate Creek. This is one of the several Alaskan districts in which platinum has been discovered.

### KENAI PENINSULA.

Improvements made during 1916 on the old Alaska Northern Railroad, now under Government ownership, stimulated prospecting on Kenai Peninsula.

Gold lode mining was limited to development work on a few properties and assessment work on others. Seven lode properties on Kenai Peninsula produced about 700 tons of ore, which yielded gold to the value of about $17,000.

Although work was done on a number of large placer projects during 1916, there was no increase in the placer production as compared with that of 1915. The last information available indicates that the yield of placer gold of Kenai Peninsula in 1916 had a value of about $70,000. This was produced from about 15 mines, the largest of which were on Crow and Resurrection creeks.

### SUSITNA REGION.

#### WILLOW CREEK DISTRICT.

Developments in the Willow Creek lode district were stimulated in 1916 by the success of several mining ventures and by the fact that railway construction in 1917 will make the district readily accessible from the town of Anchorage.

Though much more development work was done than in 1915, most of the mines had not reached a productive basis. Four lode mines were operated in 1916 and 12,182 tons of ore was milled, which yielded $299,183 in gold and 1,468 ounces of silver, valued at $966.

In 1915 three lode mines operating in the Willow Creek district produced 6,717 tons of ore from which gold valued at $247,267 was recovered. In 1916 a little gold was also recovered from placers of Willow Creek incidentally to the annual assessment work.

### YENTNA DISTRICT.

Owing to lack of water in the early part of the season, placer mining was not so extensive as in some previous years. It is estimated that about 20 mines were operated for at least part of the summer and that gold to the value of about $60,000 was recovered. The mines are scattered pretty well over the entire district and include a number of small hydraulic plants. The most important event of the year in the Yentna placer district was the installation of a dredge on Cache Creek.

### UPPER SUSITNA BASIN.

Placer mining was carried on in the upper Susitna basin in the Valdez Creek district. One large hydraulic plant was operated on Valdez Creek, and a smaller one on its tributary Lucky Gulch.

There was considerable prospecting in the Broad Pass district and the discovery of large bodies of low-grade ores carrying gold, silver, lead, and copper have been reported.

### SOUTHWESTERN ALASKA.

Some developments were made on copper deposits of the Iliamna region, notably on the McNeil claims, near Kamishak Bay, from which a test shipment of ore was made.

A small cyaniding plant has been installed and operated to treat the old tailings of the Apollo mine on Unga Island. It is reported that auriferous quartz was discovered in 1916 on the south side of Unga Island about 3 miles from the Apollo mine.

## YUKON BASIN.

### GENERAL STATEMENT.

The value of the output of placer gold in the Alaska Yukon districts in 1916 is estimated at $7,550,000, compared with $7,050,000 in 1915. About 390 placer mines were operated in the summer of 1916, and about 150 were operated in the previous winter. Several small lode mines were productive in the Yukon basin, all of which were in the Fairbanks district. The following table gives the estimated output of gold in the principal Yukon placer camps:

*Estimated value of gold produced from placers in the Yukon basin, 1916.*

| District. | Value. | District. | Value. |
|---|---|---|---|
| Iditarod | $1,950,000 | Marshall | $320,000 |
| Fairbanks | 1,800,000 | Circle | 300,000 |
| Ruby | 850,000 | All others | 510,000 |
| Hot Springs | 800,000 | | |
| Tolovana | 700,000 | | 7,550,000 |
| Koyukuk | 320,000 | | |

The Yukon placer mines also produced silver valued at $29,189 in 1916. The figures in the table do not include the output of the lode mines, which in 1916 produced gold and silver valued at $39,469.

Since mining began in 1880, the Alaska Yukon has produced minerals to the value of approximately $104,050,000, most of which has been derived from the gold placers.

### FAIRBANKS DISTRICT.

The total value of the gold and silver production in the Fairbanks district up to the end of 1916 is $68,739,951. Much the larger part of this amount represents the value of placer gold and silver, which is shown by years in the following table:

*Placer gold and silver produced in the Fairbanks district, 1903–1916.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1903 | 1,935.00 | $40,000 | 348 | $188 |
| 1904 | 29,025.00 | 600,000 | 5,225 | 2,821 |
| 1905 | 290,250.00 | 6,000,000 | 52,245 | 28,212 |
| 1906 | 435,375.00 | 9,000,000 | 78,367 | 42,318 |
| 1907 | 387,000.00 | 8,000,000 | 69,660 | 37,616 |
| 1908 | 445,050.00 | 9,200,000 | 79,909 | 43,151 |
| 1909 | 466,818.75 | 9,650,000 | 84,027 | 45,375 |
| 1910 | 295,087.50 | 6,100,000 | 53,116 | 28,683 |
| 1911 | 217,687.50 | 4,500,000 | 52,245 | 27,690 |
| 1912 | 200,756.25 | 4,150,000 | 48,182 | 29,632 |
| 1913 | 159,637.50 | 3,300,000 | 20,274 | 12,245 |
| 1914 | 120,937.50 | 2,500,000 | 29,024 | 16,050 |
| 1915 | 118,518.75 | 2,450,000 | 28,444 | 14,421 |
| 1916 | 87,075.00 | 1,800,000 | 11,058 | 7,276 |
| | 3,255,153.75 | 67,290,000 | 612,124 | 335,678 |

This table shows that the production of placer gold in the Fairbanks district has been decreasing for seven years, a fact due to the exhaustion of the bonanza deposits; but the decrease does not imply that the placer gold reserves are approaching exhaustion. It is estimated that about 115 placer mines were operated in the Fairbanks district in 1916.

There was little gold lode mining in the Fairbanks district in 1916. This is a temporary condition brought about by the decision of mine owners to suspend operations pending the completion of the Government railroad and an accompanying reduction in the cost of mining. The following table gives the production of the Fairbanks district by years since lode mining began:

*Lode gold and silver produced in the Fairbanks district, 1910–1916.*

| Year. | Total quantity of crude ore (tons). | Gold. | | Silver. | |
|---|---|---|---|---|---|
| | | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1910 | 148 | 841.19 | $17,339 | 106 | $57 |
| 1911 | 875 | 3,103.02 | 64,145 | 582 | 308 |
| 1912 | 4,708 | 9,416.54 | 194,657 | 1,578 | 971 |
| 1913 | 12,237 | 16,904.98 | 349,457 | 4,124 | 2,491 |
| 1914 | 6,526 | 10,904.75 | 225,421 | 2,209 | 1,222 |
| 1915 | 5,845 | 10,534.91 | 217,776 | 1,796 | 910 |
| 1916 | 1,111 | 1,904.81 | 39,376 | 140 | 93 |
| | 31,450 | 53,610.20 | 1,108,221 | 10,535 | 6,052 |

### CHISANA DISTRICT.

Placer mining in the Chisana district in 1916 was hampered by lack of water, and hence the output of gold amounted to only $40,000, compared with $160,000 for the year 1915. Twelve mines were operated during the summer of 1916 and two during the preceding winter.

### FORTYMILE AND EAGLE DISTRICTS.

Mining operations in the Fortymile and Eagle districts are chiefly on a small scale. About 50 placer mines were operated in this field in 1916 and gold valued at about $75,000 was produced.

### TOLOVANA DISTRICT.

The value of the gold produced in 1916 from the Tolovana district was about $700,000; the output in 1915 was valued at $80,000. Most of this gold came from deep placers on Livengood Creek, where about 15 mines were operated during the winter and 21 during the summer. One deep mine was operated on Myrtle Creek during the summer.

### CIRCLE PRECINCT.

The Circle precinct includes the Birch Creek district and the placers of Woodchopper, Beaver, and other creeks. About 27 small deep mines were worked in the winter and 40 during the summer. These mines produced gold to the value of about $300,000. In 1915 50 mines produced about $230,000.

### RAMPART DISTRICT.

Four mines were worked in the Rampart district in the winter and eight in the summer in 1916. The value of the total gold output was about $40,000. This includes the production of Quail Creek, formerly in the Rampart district but now in the Tolovana district.

### HOT SPRINGS DISTRICT.

The Hot Springs placer mines are estimated to have produced gold to the value of $800,000 in 1916, as compared with $610,000 in 1915. Most of the 16 mines were operated on a large scale. There was no productive work during the winter. Much the largest operations were in the deep gravels of Woodchopper Creek. The placers in the vicinity of Eureka Creek were the second largest producers.

### RUBY DISTRICT.

The value of the gold produced in the Ruby district in 1916 is estimated at $850,000. Forty mines were operated during the summer, and about a dozen in the previous winter. Most of the mining was of deep gravels. The completion of a dredge on Greenstone Creek was the most important mining event of the year.

### INNOKO DISTRICT.

It is estimated that the mines of the Innoko district produced gold to the value of $220,000 in 1916, compared with $190,000 in 1915.

About 35 mines were worked in the summer and 15 in the winter. The mines of Yankee Creek had the largest output and those of Gaines Creek the second largest.

In March, 1916, gold was discovered about 30 miles from Ophir, on Boob Creek, a tributary of Mastodon Creek, which flows into Tolstoi River. This discovery caused considerable excitement, but its importance is still in doubt. A little platinum occurs in the Boob Creek placers.

### IDITAROD DISTRICT.

Mining in the Iditarod district in 1916 consisted chiefly, as in the past, in a few large operations. Fifteen placer mines were operated during the summer, but practically no mining was done in the winter. These mines produced gold to the value of $1,950,000; in the preceding year 24 mines were operated, and the value of the gold output was $2,050,000. The operating plants included 3 dredges, 1 drag-line excavator, 4 scrapers, and 7 open-cut mines, operated chiefly by hydraulic methods. It is estimated that 1,580,000 cubic yards of gravel was excavated. This enormous yardage was due to the extensive dredging operations on Flat and Otter creeks.

### KOYUKUK DISTRICT.

The Koyukuk district, including the placers of Indian River, is estimated to have produced gold to the value of $320,000 in 1916 and $290,000 in 1915. Fourteen mines were operated in the district during the winter and produced gold to the value of about $240,000. A large part of this gold was from a few rich claims on Hammond River and Nolan Creek. During the summer 29 mines were operated, of which 8 were in the Indian River region.

### MARSHALL DISTRICT.

In 1916 rich placers were developed on Willow Creek, in the Marshall district, and as a consequence the value of the gold output of that district increased from $25,000 in 1915 to $320,000 in 1916. This output came from 7 mines.

### SMALLER YUKON DISTRICTS.

Three placer mines were operated in the Chandalar district in 1916 and produced about $9,000 in gold.

The Richardson district of the Tanana region produced in 1916 gold valued at about $80,000.

There were no large mining operations in either the Bonnifield or the Kantishna districts during 1916. Some production was made from 27 claims in the two districts, and the value of the total output is estimated at $40,000.

## KUSKOKWIM REGION.

Inadequate mail facilities make it difficult to obtain statistics from the Kuskokwim region, but from the data at hand it appears that the value of the gold output in 1916 was about $80,000. This came from

as widely separated districts as Candle Creek, tributary to the Takotna, and the Goodnews Bay district, and was produced from about 25 mines. Gold is widely distributed in the Kuskokwim basin. Few rich placers have been found, though apparently there are many localities where there are considerable bodies of auriferous gravel that deserve systematic prospecting.

### SEWARD PENINSULA.

The mines of Seward Peninsula produced gold valued at about $2,950,000 in 1916 and $2,900,000 in 1915. The value of the total gold production since mining began in 1897 is about $74,292,000.

The year 1916 was favorable for placer mining on account of the ample supply of water. And in consequence more mines were operated than in 1915. It is estimated that, including the dredges, 148 mines were operated in 1916, compared with 120 in 1915.

Twenty-seven gold dredges were operated in 1916, which handled about 1,870,000 cubic yards of gravel that yielded gold to the value of $985,000. In 1915, 31 gold dredges were operated, which handled 3,000,000 cubic yards of gravel, that yielded gold to the value of $1,050,000. This comparison shows that there was a tendency to restrict dredge mining to richer gravels in 1916 than in 1915.

It is estimated that about 66 deep gravel mines were operated on the peninsula in 1916. Many of these were operated in winter as well as in summer. In addition to the dredges, about 70 open-cut mines were operated during the summer. Mining was done on a larger scale in the Koyuk district than in any previous year. The value of the gold produced in this district in 1915 was only $3,000, whereas that of the winter output alone in 1916 was $100,000. Complete returns on the summer operations in the Koyuk district are not yet available.

### KOBUK REGION.

Placer mining continued in a small way during 1916 in the Kobuk region. Details are lacking, but it is probable that the value of the gold output in 1916 was about the same as in 1915 which was estimated at $20,000.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN NEW MEXICO.[1]

(MINES REPORT.)

By CHARLES W. HENDERSON.

## PRODUCTION.

The total value of the gold, silver, copper, lead, and zinc produced from New Mexico ores and gravels in 1916 amounted to $30,827,767, as compared with $19,279,468 in 1915, an increase of $11,548,299, or nearly 60 per cent. There were 210 producing mines, of which 191 were deep and 19 were placer, an increase of 43 deep mines, but a decrease of 7 placers. The yield of gold was 66,877.47 fine ounces, valued at $1,382,480, a decrease of 3,803.49 fine ounces in quantity and of $78,625 in value. The output of silver was 1,766,274 fine ounces, valued at $1,162,208, a decrease of 239,257 fine ounces in quantity, but an increase of $145,404 in value. The output of copper was 92,747,289 pounds, an increase of 15,958,923 pounds; the output of lead (calculated as lead in lead bullion and lead in leaded-zinc oxide) was 8,214,189 pounds, an increase of 3,671,828 pounds; and the output of zinc (calculated as spelter and as zinc in leaded-zinc oxide) was 36,570,649 pounds, an increase of 11,166,585 pounds. The value of the base metals showed an increase of $9,377,869 for copper, of $353,288 for lead, and of $1,750,363 for recoverable zinc (valued at the prices estimated by the United States Geological Survey for each year). There were 3,870,950 short tons of ore sold or treated in 1916, as compared with 2,797,072 tons in 1915.

*Mine production of gold, silver, copper, lead, and zinc in New Mexico, 1904–1916.*

| Year. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine oz.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 102,339 | $381,930 | 214,553 | 4,972,170 | 3,122,872 | 13,493,835 | $1,961,390 |
| 1905 | 145,629 | 317,510 | 369,192 | 6,126,025 | 1,510,209 | 15,142,254 | 2,460,535 |
| 1906 | 207,691 | 293,019 | 491,127 | 7,028,670 | 2,987,369 | 17,292,655 | 3,203,739 |
| 1907 | 219,992 | 329,982 | 705,544 | 10,990,015 | 3,809,881 | 750,085 | 3,239,823 |
| 1908 | 135,434 | 298,757 | 405,044 | 6,112,630 | 873,763 | 3,576,516 | 1,525,091 |
| 1909 | 164,156 | 239,491 | 397,783 | 5,393,146 | 5,029,767 | 13,085,945 | 2,070,368 |
| 1910 | 191,865 | 482,424 | 843,987 | 4,614,386 | 4,320,841 | 18,088,129 | 2,691,080 |
| 1911 | 232,699 | 762,808 | 1,354,540 | 4,057,040 | 2,966,222 | 10,237,176 | 2,704,843 |
| 1912 | 1,352,286 | 784,446 | 1,536,701 | 34,030,964 | 5,494,018 | 13,566,637 | 8,527,955 |
| 1913 | 2,217,660 | 881,926 | 1,631,273 | 56,308,706 | 3,946,304 | 16,523,161 | 11,694,002 |
| 1914 | 2,232,853 | 1,171,696 | 1,777,445 | 59,307,925 | 1,763,641 | 18,403,392 | 11,049,932 |
| 1915 | 2,797,072 | 1,461,105 | 2,005,531 | 76,788,366 | 4,542,361 | 25,401,064 | 19,279,468 |
| 1916 | 3,870,950 | 1,382,480 | 1,766,274 | 92,747,289 | 8,214,189 | 36,570,649 | 30,827,767 |
| Increase or decrease, 1916. | +1,073,878 | −78,625 | −239,257 | +15,958,923 | +3,671,828 | +11,166,585 | +11,548,299 |

[a] Includes placer production.

[1] For discussion of the geology of the districts mentioned in the following pages the reader is referred to the bibliography appended to the report for 1912 in Mineral Resources for 1912, pt. 1, p. 819, 1913; to U. S. Geol. Survey Bull. 507 (The mining districts of the Western United States, by J. M. Hill, with a geologic introduction by Waldemar Lindgren), 1912; and to U. S. Geol. Survey Prof. Paper 68 (The ore deposits of New Mexico, by Waldemar Lindgren), 1910.

During 1916 there were treated at amalgamating and cyaniding mills in New Mexico 135,267 tons of ore, and the bullion saved amounted to $709,712 in gold, an average value per ton of $5.247, and 841,865 ounces of silver, valued at $553,947, an average recovery of 6.22 ounces and an average value per ton of $4.095, the value in gold and silver being $1,263,659, an average value per ton of $9.342. The recovery as bullion per ton of ore treated in 1915 was $5.59 in gold and $3.83 in silver, a total of $9.42.

## GOLD.

The recoverable production of gold from New Mexico ores and gravels in 1916 amounted to 66,877.47 fine ounces, valued at $1,382,480, as against 70,680.96 fine ounces, valued at $1,461,105 in 1915, a decrease of 3,803.49 fine ounces in quantity and of $78,625 in value. Colfax County alone produced 20,428.62 fine ounces, valued at $422,297, or nearly 31 per cent of the total State yield; Grant County produced 20,301.78 fine ounces, valued at $419,675, or 30 per cent; and Socorro County (chiefly from the siliceous mines at Mogollon) produced 18,146.67 fine ounces, valued at $375,125, or 27 per cent of the total. Dry and siliceous ores yielded 54,360.53 fine ounces, valued at $1,123,732, or 81 per cent of the total. Copper ores contained 11,336.28 fine ounces, valued at $234,342, or 17 per cent of the total, chiefly from Central and Lordsburg districts, Grant County, and from San Pedro district, Santa Fe County. Lead ores furnished 319.29 fine ounces, valued at $6,600, chiefly from the Victorio district, Luna County, and the Magdalena district, Socorro County. Copper-lead ores furnished a small quantity of gold. The production of placer gold amounted to 537.74 fine ounces, valued at $11,116.

## SILVER.

The recoverable yield of silver from New Mexico ores and gravels in 1916 amounted to 1,766,274 fine ounces, valued at $1,162,208, as compared with 2,005,531 fine ounces, valued at $1,016,804 in 1915, a decrease of 239,257 fine ounces in quantity, but an increase of $145,404 in value. Of the total quantity Socorro County produced 1,081,711 fine ounces, or 61 per cent, chiefly from siliceous ore from the Mogollon district, the remainder from mixed ores of the Magdalena district. Grant County furnished 549,907 fine ounces, or 31 per cent of the total, cheifly from the Lordsburg district, though there was also a considerable quantity from the Central district. The yield of silver from Grant and Socorro counties combined was 92 per cent of the total.

Dry and siliceous gold and silver ore, chiefly from Socorro, Grant, and Sandoval counties, yielded 1,436,172 fine ounces of silver, or more than 81 per cent of the total; copper ores, chiefly Grant, Santa Fe, and Socorro counties, yielded 231,091 ounces, or 13 per cent; lead ores, chiefly from the Central district, Grant County, the Florida Mountains and Victorio districts, Luna County, and the Magdalena district, Socorro County, furnished 75,704 ounces, or more than 4 per cent; copper-lead ores, chiefly from the Central district, Grant County, and the Magdalena district, Socorro County, furnished 11,118 ounces, or less than 1 per cent. Lead-zinc ores, chiefly from concentrates produced from such ores in the Pinos Altos district,

Grant County, and the Cerrillos district, Santa Fe County, yielded 12,117 ounces, or less than 1 per cent.

### COPPER.

In 1916 the production of copper in New Mexico amounted to 92,747,289 pounds, valued at $22,815,833, an increase of 15,958,923 pounds and $9,377,869, as compared with the output in 1915. Grant County, chiefly from the output of the Chino Copper Co., at Santa Rita, and from Lordsburg and Burro Mountain districts, produced 87,784,545 pounds, or nearly 95 per cent of the total. The increase for the year in Grant County was 15,297,345 pounds, there being an an increase of 7,647,240 pounds in Central district, an increase of 6,986,043 in the Burro Mountain district, an increase of 864,814 pounds in the Lordsburg district, and decreases in some of the small districts. The yield from Otero County increased 294,224 pounds; that from Santa Fe County, 448,753 pounds; while that from Socorro County decreased 402,834 pounds.

Copper ores, chiefly from Dona Ana, Grant, Otero, Santa Fe, Socorro, Torrance, and Valencia counties, yielded 87,593,495 pounds, or over 94 per cent of the total; dry and siliceous gold and silver ore (chiefly from the dry ore of Otero County and from the siliceous ore of Lordsburg district, Grant County), yielded 4,873,810 pounds, or 5 per cent; lead ores, chiefly from the Magdalena district, Socorro County, yielded 130,294 pounds; and copper-lead ores, chiefly from the Central district, Grant County, and the Magdalena district, Socorro County, 108,378 pounds.

There were 12,511,885 pounds of copper contained in crude ore shipped to smelters, or 13 per cent of the total production, and concentrates contained 80,235,404 pounds, or 87 per cent.

### LEAD.

In 1916 the production of lead amounted to 8,214,189 pounds, valued at $566,779, an increase of 3,671,828 pounds in quantity and of $353,288 in value.

The principal lead-producing districts were the Carpenter, Central, Pinos Altos, and San Simon districts, Grant County; the Magdalena district, Socorro County; the Cooks Peak, Florida Mountains, Tres Hermanas, and Victorio districts, Luna County; and the Cerrillos district, Santa Fe County. Socorro County yielded 4,424,522 pounds; Grant County, 2,561,638 pounds; and Luna County, 868,724 pounds. Concentrates contained 727,888 pounds, and crude ores shipped to smelters contained 7,486,301 pounds. Lead ores furnished 5,950,399 pounds; zinc and lead-zinc ores, 1,895,730 pounds; and copper-lead ores, 218,319 pounds—the combined content of these classes of ores representing 98 per cent of the total.

### ZINC.

The total recoverable zinc, whether marketed as spelter or as oxide, from crude ore and concentrates, shipped from New Mexico in 1916 and calculated in terms of spelter and zinc in the various forms of zinc oxide, was 36,570,649 pounds, valued (in terms of the Survey's average price of spelter for the year) at $4,900,467. The value for the output of zinc in New Mexico for 1916 was $3,517,987

more than that of the gold and $3,833,633 more than that of the silver.

Mines producing zinc in New Mexico in 1915 were at Kelly, Socorro County; in the Carpenter, Central, and Pinos Altos districts, Grant County; Cooks Peak, Florida Mountains, and Tres Hermanas districts, Luna County; Cerrillos district, Santa Fe County; Hermosa district, Sierra County; and Organ Mountains district, Dona Ana County.

*Zinc ore and concentrates marketed in New Mexico, 1915–16, and average assay of zinc.*

| Year. | Quantity. | Average assay. |
|---|---|---|
| | *Short tons.* | *Per cent.* |
| 1915 | 41,852 | 36.00 |
| 1916 | 74,944 | 29.16 |
| Increase | 33,092 | ..... |

## PLACER OUTPUT.

*Placer output in New Mexico in 1916.*

| County. | Gold. | | Silver. | | Total value. |
|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | |
| | *Fine ounces.* | | *Fine ounces.* | | |
| Colfax | 243.76 | $5,039 | 29 | $19 | $5,058 |
| Grant | 97.19 | 2,009 | 29 | 19 | 2,028 |
| Lincoln | 31.49 | 651 | 3 | 2 | 653 |
| Otero | 14.76 | 305 | 2 | 1 | 306 |
| Santa Fe | 150.54 | 3,112 | 9 | 6 | 3,118 |
| Total, 1916 | 537.74 | 11,116 | 72 | 47 | 11,163 |
| Total, 1915 | 447.09 | 9,242 | 55 | 28 | 9,270 |
| Increase | 90.65 | 1,874 | 17 | 19 | 1,893 |

## CONTENT OF ORES.

*Content of copper ores sold or treated in New Mexico in 1916.*

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Dona Ana | 2,238 | 3.00 | 7,685 | 206,187 | 14,722 |
| Grant | 3,384,282 | 7,338.45 | 151,594 | 83,121,210 | 79,464 |
| Guadalupe | 23 | ..... | 8 | 1,463 | ..... |
| Lincoln | 106 | ..... | 47 | 27,793 | ..... |
| Luna | 22 | ..... | 65 | 1,362 | ..... |
| Otero | 12,079 | 726.02 | 4,401 | 810,924 | 5,408 |
| Rio Arriba | 44 | .87 | 2,956 | 6,553 | ..... |
| Sandoval | 130 | .39 | 274 | 26,276 | 116 |
| Santa Fe | 40,137 | 3,197.88 | 29,687 | 2,153,610 | ..... |
| Sierra | 73 | 54.01 | 1,039 | 9,506 | 246 |
| Socorro | 10,541 | 11.02 | 30,071 | 885,774 | 7,500 |
| Taos | 63 | 4.64 | 664 | 11,362 | ..... |
| Torrance and Valencia | 3,172 | ..... | 2,600 | 331,475 | ..... |
| | 3,452,910 | 11,336.28 | 231,091 | 87,593,495 | 107,456 |

*Content of dry and siliceous gold and silver ores sold or treated in New Mexico in 1916.*

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Colfax | 6,064 | 20,184.86 | 2,774 | 447 | ..... |
| Dona Ana | 70 | 12.33 | 13 | ..... | ..... |
| Grant | 119,065 | 12,501.12 | 363,768 | 4,518,486 | 16,157 |
| Lincoln | 1,384 | 343.12 | 903 | 252 | ..... |
| Luna | 500 | 7.00 | 543 | ..... | 19,258 |
| Otero | 9,715 | 1,186.01 | 3,512 | 354,092 | 638 |
| Sandoval | 9,300 | 2,070.93 | 56,404 | ..... | ..... |
| Sierra | 7 | 17.00 | 22 | 120 | ..... |
| Socorro | 118,253 | 18,038.16 | 1,008,233 | 413 | 3,232 |
| | 264,358 | 54,360.53 | 1,436,172 | 4,873,810 | 39,285 |

*Content of lead ores sold or treated in New Mexico in 1916.*

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Bernalillo | 24 | 0.24 | 32 | ..... | 14,188 |
| Dona Ana | 91 | 9.00 | 250 | ..... | 19,974 |
| Grant | 4,117 | 63.02 | 21,285 | 21,255 | 2,157,945 |
| Luna | 2,093 | 164.01 | 17,469 | 1,301 | 847,313 |
| Otero | 44 | ..... | 13 | 1,956 | 11,346 |
| Santa Fe | 3 | .07 | 29 | ..... | 3,987 |
| Sierra | 800 | ..... | 477 | ..... | 115,160 |
| Socorro | 7,753 | 82.95 | 36,149 | 105,782 | 2,780,486 |
| | 14,925 | 319.29 | 75,704 | 130,294 | 5,950,399 |

*Content of zinc and lead-zinc ores sold or treated in New Mexico in 1916.*

| County. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Dona Ana | 216 | ..... | ..... | ..... | ..... | 106,679 |
| Grant and Luna | 74,645 | 291.00 | 9,199 | 41,144 | 146,114 | 16,810,425 |
| Santa Fe | 2,543 | 7.09 | 2,146 | ..... | 162,317 | 334,321 |
| Sierra | 15 | ..... | ..... | ..... | ..... | 7,045 |
| Socorro | 60,277 | .54 | 772 | 168 | 1,590,299 | 19,312,179 |
| | 137,696 | 298.63 | 12,117 | 41,312 | 1,898,730 | 36,570,649 |

*Content of copper-lead ores sold or treated in New Mexico in 1916.*

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Grant | 774 | 11.00 | 4,032 | 82,450 | 164,111 |
| Sierra | 40 | ..... | 600 | 4,801 | 11,203 |
| Socorro | 247 | 14.00 | 6,486 | 21,127 | 43,005 |
| | 1,061 | 25.00 | 11,118 | 108,378 | 218,319 |

## SMELTERS.

One smelter was in operation in New Mexico in 1916, the Santa Fe Gold & Copper Co.'s 125-ton matting plant at San Pedro, which was operated on copper ore from its own mines.

The bulk of the copper ore and concentrates continued to be shipped to the smelter at El Paso, Tex. A considerably increased quantity of lead ores and concentrates were shipped to Pueblo, Colo. Shipments

were also made to the Copper Queen smelter and the Calumet & Arizona smelter, at Douglas, Ariz., and the smelter at Sasco, Ariz. Some bullion was shipped to Selby, Cal., and matte to Omaha, Nebr. Zinc ore and concentrates were shipped to smelters and zinc oxide plants in Colorado, Kansas, Oklahoma, Wisconsin, and the Eastern States.

## MINING INDUSTRY.

The Mogollon district, Socorro County (80 miles distant from the railroad point Silver City, Grant County), continued to be the most important silver-producing district, but gave way to the Elizabethtown district, Colfax County, in production of gold. The yield from the Mogollon district in 1916 was $373,068 in gold and 1,008,483 ounces of silver, a decrease of $136,097 in gold and of 292,576 ounces of silver, as compared with the output in 1915. The gold from this district represented 27 per cent of the State's production of this metal, and the silver was 57 per cent of the State's total silver output. The Mogollon Mines Co.'s mill was operated steadily on ore from the company's Last Chance and Top mines, and the Fanney mill, of the Socorro Mining & Milling Co., was operated continuously on ore from the company's mines and from various other properties in the district. The Oaks Co. did much development work. The product of the mills is chiefly refined silver-gold bullion from cyanide precipitates, the remainder being high-grade gold-silver concentrates. In terms of recovered metal, the ore averaged per ton 0.1526 ounce, or $3.15, in gold and 8.52 ounces, or $5.61, in silver. The leading district in the production of gold was Elizabethtown (Baldy) district, Colfax County, which produced a small quantity of gold from various placers and a considerable quantity of high-grade metallic gold, gold bullion, and concentrates from the Aztec mine, at Baldy. The Lordsburg district, Grant County, again increased its shipments of gold and silver bearing copper and dry ores, the gold output increasing $44,300 but the silver yield decreasing 1,251 ounces. The small gold and silver credit realized from the smelter from the copper concentrates of the Chino Copper Co. amounted to $80,498 and represented a credit of 0.11 cent a pound of copper produced in 1916 against 0.12 cent in 1915. A small yield of gold-silver bullion was made from the Gold Hill district, north of Lordsburg, and the Steeplerock district (reopened in 1915), Grant County, again contributed some gold and silver. The continuous operation of the mines and matte smelter of the Santa Fe Gold & Copper Co., at San Pedro, SantaFe County, also contributed to the gold output. Shipments of gold-copper ore from the Jarilla district, Otero County, increased in weight of ores shipped, but the gold and silver contained in the ore was not equal to the content in 1915. Operations at the 100-ton cyanidation plant of the Cossak Mining Co., in the Cochiti (Bland) district, Sandoval County, were resumed (after an idleness from December, 1916) in April, 1917, and were continued through November, with an important yield of silver-gold bullion. The amalgamation mill at Homestake mine, Whiteoaks, Lincoln County, was operated for a period.

Copper has always been an important metal in the yield of New Mexico mines, and for 1916 the yield was the largest on record. The Chino Copper Co., which since 1910 has been mining with steam shovels large low-grade copper deposits at Santa Rita, reports that

for the year 1916 there was treated in the large milling plant at Hurley a total of 3,094,400 tons of ore, equivalent to an average of 8,455 tons a day. The improvements and extensions made at both mines and mill during 1916 and 1915 will materially increase the yield in 1917. The new tailings re-treatment plant will also add substantially to the production for several years. The Burro Mountain Copper Co.'s 1,000-ton mill, in the Burro Mountain district, was set in motion in April, 1916, and contributed a very considerable quantity of silver-copper concentrates. Lessees' operations at this property also yielded an appreciable quantity of copper ore. The copper output of Lordsburg, Grant County, increased 22 per cent, and the yield was the largest in the history of that district. The mines and copper-matting plant at San Pedro, Santa Fe County, was operated continuously. The output of copper from the Jarilla district, Otero County, with some yield also from the Highrolls and Tularosa districts in the same county, showed an increase for Otero County of 33 per cent. A large quantity of low-grade copper ore, having calcite gangue, valuable for its fluxing qualities, was shipped from the Apache mine, Hachita. The yield of copper from the Organ district, Dona Ana County, made by lessees on various properties, fell off slightly. Early in 1916 the Phelps Dodge Co. took options on and actively prospected a large part of this district. The high prices of copper resulted in shipments from various deposits in the "Red Beds" of New Mexico, some from hitherto known districts, such as the Oscuro Mountains, San Andres Mountains, Nacimiento Mountains, and also an appreciable yield from the new discovery (in 1915) in the Carocito (Manzano Mountains) district, near Scholle and Mountainair, Torrance and Valencia counties. A small yield of copper was also made from Mesozoic sandstones in the Pintada Canyon, Guadalupe County.

The output of lead increased 80 per cent in quantity. Large quantities of lead carbonate ore and also lead-zinc sulphide ores were shipped from the Magdalena district, Socorro County; lead ores were also shipped from the Cooks Peak, Florida Mountains, Tres Hermanas, and Victorio districts, Luna County; from the Carpenter, Central, Kimball, and San Simon districts, Grant County; from the Caballos Mountains, Sierra County; and lead concentrates from the Cerrillos district, Santa Fe County.

Shipments of zinc carbonate, zinc sulphide, and zinc-lead sulphide ores and zinc and lead-zinc sulphide concentrates from New Mexico in 1916 again showed a large increase. At Kelly, Socorro County, the Empire Zinc Co.'s magnetic separation mill was operated on zinc-lead sulphide ores of the Kelly mine and the Ozark flotation mill was operated on the sulphide ores from the Graphic mine until the mill was destroyed by fire in August. Large quantities of zinc carbonate ores were also shipped from Kelly, principally from the Graphic, Juniata, and Kelly mines. The Empire Zinc Co.'s Hanover magnetic separation mill, at Hanover, Grant County, was operated from June, 1916, and its Cleveland mill, in the Pinos Altos district, was operated throughout the year. The Pinos Altos Mining & Milling Co.'s wet concentration-electrostatic mill was operated for a period. Zinc carbonate ores were shipped from the Empire Zinc Co.'s Hanover property and from several other properties at Hanover. A large quantity of zinc carbonate ore was shipped from the Cooks Peak, Florida

Mountains, and Tres Hermanas districts, Luna County. Several cars of zinc carbonate ore were shipped from the Organ Mountains district, Luna County, and a car of zinc carbonate ore was shipped from the Hermosa district, Sierra County. Lead-zinc concentrates were shipped from the Cerrillos district.

*Mine production of gold, silver, copper, lead, and zinc in New Mexico in 1916.*

| County. | Number of mines producing. | Ore. | Gold.[a] | | Silver.[a] | |
|---|---|---|---|---|---|---|
| | | | Quantity. | Value. | Quantity. | Value. |
| | | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | |
| Bernalillo | 1 | 24 | 0.24 | $5 | 32 | $21 |
| Colfax | 4 | 6,064 | 20,428.62 | 422,297 | 2,803 | 1,844 |
| Dona Ana | 9 | 2,615 | 24.33 | 503 | 7,948 | 5,230 |
| Grant | 85 | 3,577,868 | 20,301.78 | 419,675 | 549,907 | 361,839 |
| Guadalupe | 1 | 23 | ..... | ..... | 8 | 5 |
| Lincoln | 6 | 1,490 | 374.61 | 7,744 | 953 | 627 |
| Luna | 16 | 7,630 | 171.01 | 3,535 | 18,077 | 11,895 |
| Otero | 26 | 21,838 | 1,926.79 | 39,830 | 7,928 | 5,216 |
| Rio Arriba | 4 | 44 | .87 | 18 | 2,956 | 1,945 |
| Sandoval | 3 | 9,430 | 2,071.32 | 42,818 | 56,678 | 37,294 |
| Santa Fe | 10 | 42,683 | 3,355.58 | 69,366 | 31,871 | 20,971 |
| Sierra | 10 | 935 | 71.01 | 1,468 | 2,138 | 1,407 |
| Socorro | 20 | 197,071 | 18,146.67 | 375,125 | 1,081,711 | 711,766 |
| Taos | 2 | 63 | 4.64 | 96 | 664 | 437 |
| Torrence and Valencia | 13 | 3,172 | ..... | ..... | 2,600 | 1,711 |
| Total, 1916 | 210 | 3,870,950 | 66,877.47 | 1,382,480 | 1,766,274 | 1,162,208 |
| Total, 1915 | 174 | 2,797,072 | 70,680.96 | 1,461,105 | 2,005,531 | 1,016,804 |
| Increase or decrease | +36 | +1,073,878 | −3,803.49 | −78,625 | −239,257 | +145,404 |

| County. | Copper. | | Lead. | | Zinc. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value.[b] | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Bernalillo | ..... | ..... | 14,188 | $979 | ..... | ..... | $1,005 |
| Colfax | 447 | $110 | ..... | ..... | ..... | ..... | 424,251 |
| Dona Ana | 206,187 | 50,722 | 34,696 | 2,394 | 106,679 | $14,295 | 73,144 |
| Grant | 87,784,545 | 21,594,998 | 2,561,638 | 176,753 | (b) | (b) | 22,553,265 |
| Guadalupe | 1,463 | 360 | ..... | ..... | ..... | ..... | 365 |
| Lincoln | 28,045 | 6,899 | ..... | ..... | ..... | ..... | 15,270 |
| Luna | 2,663 | 655 | 868,724 | 59,942 | (b) | (b) | 76,027 |
| Otero | 1,166,972 | 287,075 | 17,392 | 1,200 | ..... | ..... | 333,321 |
| Rio Arriba | 6,553 | 1,612 | ..... | ..... | ..... | ..... | 3,575 |
| Sandoval | 26,276 | 6,464 | 116 | 8 | ..... | ..... | 86,584 |
| Santa Fe | 2,153,610 | 529,788 | 166,304 | 11,475 | 334,321 | 44,799 | 676,399 |
| Sierra | 14,427 | 3,549 | 126,609 | 8,736 | 7,045 | 944 | 16,104 |
| Socorro | 1,013,264 | 249,263 | 4,424,522 | 305,292 | 19,312,179 | 2,587,832 | 4,229,278 |
| Taos | 11,362 | 2,795 | ..... | ..... | ..... | ..... | 3,328 |
| Torrance and Valencia | 331,475 | 81,543 | ..... | ..... | ..... | ..... | 83,254 |
| Grant and Luna | ..... | ..... | ..... | ..... | 16,810,425 | 2,252,597 | 2,252,597 |
| Total, 1916 | 92,747,289 | 22,815,833 | 8,214,189 | 566,779 | 36,570,649 | 4,900,467 | 30,827,767 |
| Total, 1915 | 76,788,366 | 13,437,964 | 4,542,361 | 213,491 | 25,404,064 | 3,150,104 | 19,279,468 |
| Increase | 15,958,923 | 9,377,869 | 3,671,828 | 353,288 | 11,166,585 | 1,750,363 | 11,548,298 |

[a] Includes placer production.
[b] In order to avoid disclosing individual production, the production of zinc in Grant and Luna counties is combined.

*Gold and silver produced at mills in New Mexico, 1909–1916.*

| Year. | Ore to gold and silver mills. | Gold in bullion. | Silver in bullion. | Ore to concentrating mills. |
|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Short tons.* |
| 1909 | 32,830 | 6,725.84 | 169,650 | 78,782 |
| 1910 | 67,148 | 14,220.94 | 412,272 | 61,379 |
| 1911 | 109,113 | 21,894.14 | 771,014 | 59,622 |
| 1912 | 106,208 | 20,342.58 | 842,018 | 1,142,002 |
| 1913 | 124,536 | 24,891.37 | 1,024,363 | 1,987,896 |
| 1914 | 156,913 | 29,730.64 | 1,161,455 | 1,955,881 |
| 1915 | 149,650 | 40,474.37 | 1,129,701 | 2,428,344 |
| 1916 | 135,267 | 34,332.33 | 841,865 | 3,442,681 |
| Increase or decrease, 1916 | −14,383 | −6,142.04 | −287,836 | +1,014,337 |

*Mine production of metals from New Mexico concentrates, 1909–1916.*

| Year. | Concentrates produced. | | | | | |
|---|---|---|---|---|---|---|
| | Quantity. | Gold. | Silver. | Copper. | Lead. | Zinc. |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| 1909 | 7,554 | 1,598.31 | 112,639 | 2,015,118 | 436,558 | 821,766 |
| 1910 | 18,298 | 4,536.03 | 255,060 | 1,050,238 | 2,701,843 | 6,882,175 |
| 1911 | 16,243 | 7,938.70 | 333,654 | 1,125,927 | 1,562,768 | 5,304,000 |
| 1912 | 81,811 | 7,190.63 | 290,081 | 28,760,908 | 1,984,435 | 6,404,768 |
| 1913 | 198,243 | 7,913.39 | 294,948 | 51,723,923 | 1,076,848 | 8,594,183 |
| 1914 | 161,003 | 12,754.17 | 312,734 | 53,398,611 | 637 | 8,541,261 |
| 1915 | 174,074 | 12,876.72 | 323,402 | 66,326,554 | 75,580 | 11,179,266 |
| 1916 | 311,726 | 13,125.69 | 336,472 | 80,235,404 | 727,888 | 16,625,663 |
| Increase, 1916 | 137,652 | 248.97 | 13,070 | 13,908,850 | 652,308 | 5,446,397 |

*Mine production of metals from New Mexico crude ore shipped to smelters, 1909–1916.*

**By years.**

| Year. | Crude ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| 1909 | 52,544 | 2,196.50 | 115,332 | 3,378,028 | 4,593,209 | 12,264,179 |
| 1910 | 63,338 | 3,317.99 | 176,281 | 3,564,148 | 1,618,998 | 11,205,954 |
| 1911 | 63,964 | 6,162.71 | 249,710 | 2,931,113 | 1,403,454 | 4,933,176 |
| 1912 | 104,076 | 9,595.57 | 404,462 | 5,270,056 | 3,509,583 | 7,161,869 |
| 1913 | 105,228 | 9,478.13 | 311,872 | 4,584,783 | 2,869,516 | 7,928,978 |
| 1914 | 120,059 | 12,785.76 | 302,926 | 5,909,314 | 1,763,004 | 9,862,131 |
| 1915 | 219,078 | 16,882.78 | 552,373 | 10,461,812 | 4,466,781 | 14,224,798 |
| 1916 | 293,002 | 18,881.71 | 587,865 | 12,514,885 | 7,486,301 | 19,944,986 |
| Increase, 1916 | 73,924 | 1,998.93 | 35,492 | 2,050,073 | 3,019,520 | 5,720,188 |

**By kind of ores (in 1916).**

| | | | | | | |
|---|---|---|---|---|---|---|
| Dry and siliceous | 128,591 | 13,646.07 | 368,150 | 4,872,950 | 16,795 | ..... |
| Copper | 103,544 | 4,891.35 | 132,893 | 7,400,263 | 107,456 | ..... |
| Lead | 14,925 | 319.29 | 75,704 | 130,294 | 5,950,392 | ..... |
| Copper-lead | 1,061 | 25.00 | 11,118 | 108,378 | 218,319 | ..... |
| Zinc and lead-zinc | 44,881 | ..... | ..... | ..... | 1,193,332 | 19,944,986 |

*Mine production of metals from New Mexico crude ore and concentrates combined shipped to smelter, 1909–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| 1909 | 60,098 | 3,794.81 | 227,971 | 5,393,146 | 5,029,767 | 13,085,945 |
| 1910 | 81,636 | 7,854.02 | 431,341 | 4,614,386 | 4,320,841 | 18,088,129 |
| 1911 | 80,307 | 14,101.41 | 583,364 | 4,057,040 | 2,966,222 | 10,237,176 |
| 1912 | 185,887 | 16,786.20 | 694,543 | 34,030,964 | 5,494,018 | 13,566,637 |
| 1913 | 303,471 | 17,391.52 | 606,820 | 56,308,706 | 3,946,364 | 16,523,161 |
| 1914 | 281,062 | 25,539.93 | 615,660 | 59,307,925 | 1,763,641 | 18,403,392 |
| 1915 | 393,152 | 29,759.51 | 875,775 | 76,788,366 | 4,542,361 | 25,404,064 |
| 1916 | 604,728 | 32,007.40 | 924,337 | 92,747,289 | 8,214,189 | 36,570,649 |
| Increase, 1916 | 211,576 | 2,247.89 | 48,562 | 15,958,923 | 3,671,828 | 11,166,585 |

*Gold and silver produced at mills in New Mexico, 1916.*

| County. | Ore to gold and silver mills. | Gold. | Silver. | Ore to concentrating mills. |
|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Short tons.* |
| Colfax | 6,064 | 17,199.73 | 2,348 | ..... |
| Dona Ana | 70 | 2.33 | 1 | ..... |
| Grant | 220 | 58.06 | 21 | 3,406,171 |
| Lincoln | 1,360 | 343.12 | 34 | ..... |
| Luna | ..... | ..... | ..... | 500 |
| Otero | ..... | ..... | ..... | 1,160 |
| Sandoval | 9,300 | 2,070.93 | 56,404 | ..... |
| Santa Fe | ..... | ..... | ..... | 2,543 |
| Socorro | 118,253 | 14,658.16 | 783,057 | 32,283 |
| Taos | ..... | ..... | ..... | 24 |
| | 135,267 | 34,332.33 | 841,865 | 3,442,681 |

*Mine production of metals from New Mexico crude ore shipped to smelters, 1916.*

| County. | Crude ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Bernalillo | 24 | 0.24 | 32 | ..... | 14,188 | ..... |
| Dona Ana | 2,545 | 12.00 | 7,935 | 206,187 | 34,696 | 106,679 |
| Grant | 171,477 | 13,411.55 | 442,672 | 7,567,916 | 2,439,186 | (a) |
| Guadalupe | 23 | ..... | 8 | 1,463 | ..... | ..... |
| Lincoln | 130 | ..... | 916 | 28,045 | ..... | ..... |
| Grant, Luna, and Socorro | ..... | ..... | ..... | ..... | ..... | a 19,831,262 |
| Luna | 7,130 | 164.01 | 17,534 | 2,663 | 849,466 | (a) |
| Otero | 20,678 | 1,912.03 | 7,826 | 1,150,972 | 17,392 | ..... |
| Rio Arriba | 44 | .87 | 2,956 | 6,553 | ..... | ..... |
| Sandoval | 130 | .39 | 274 | 26,276 | 116 | ..... |
| Santa Fe | 40,140 | 3,197.95 | 29,716 | 2,153,610 | 3,987 | ..... |
| Sierra | 935 | 71.01 | 2,138 | 14,427 | 126,609 | 7,045 |
| Socorro | 46,535 | 107.97 | 72,706 | 1,012,683 | 4,000,661 | (a) |
| Taos | 39 | 3.69 | 552 | 9,615 | ..... | ..... |
| Torrance and Valencia | 3,172 | ..... | 2,600 | 331,475 | ..... | ..... |
| | 293,002 | 18,881.71 | 587,865 | 12,511,885 | 7,486,301 | 19,944,986 |

a In order to avoid disclosing individual production, production of zinc from Grant, Luna, and Socorro counties is combined.

*Gold and silver contained in bullion produced at mills in New Mexico, 1916.*

| Process. | Ore. | Gold in bullion. | Silver in bullion. |
|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* |
| Amalgamation | 7,594 | 17,576.20 | 2,395 |
| Cyanidation | 127,673 | 16,756.13 | 839,470 |
| | 135,267 | 34,332.33 | 841,865 |

The quicksilver consumed in New Mexico in 1916 amounted to 280 pounds, representing 1 pound for every 62.77 ounces of gold, and the sodium cyanide to 176,525 pounds, representing 1 pound for every 0.09 ounce of gold and 1 pound for every 4.76 ounces of silver.

### REDUCTION MILLS.

Mineral Resources for 1912, Part I, pages 832–835, contained a complete list of the reduction mills in New Mexico in 1912 and descriptions of equipment and process. Changes in this list for 1916 have been noted in the text for the several counties, and reference should be made to the 1912 report for details of equipment.

## REVIEW BY COUNTIES.[1]

### BERNALILLO COUNTY.

A car of silver-lead ore was shipped from the Octoroon mine, in the Soda Springs district. Assessment and development work was done in the Coyote, Hell Canyon, and Soda Springs districts.

### COLFAX COUNTY.

*Elizabethtown district (including Baldy).*—The total value of the mine production of Colfax County increased from $357,138 in 1915, to $424,251 in 1916. Placer mines in this district yielded $5,039 in gold, as compared with $2,631 in 1915. The Aztec [2] mine continued to ship gold bullion and concentrates carrying a high content of gold from the 10-stamp amalgamation-concentration mill on the property. The following table shows the production of Elizabethtown and Baldy districts (which is the output for Colfax County) from 1904 to 1916, inclusive:

*Mine production in Elizabethtown district, Colfax County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | Placer. | Deep. | | | | |
| | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 380 | $90,639 | $3,638 | 67 | ..... | ..... | $94,316 |
| 1905 | 13 | 31,994 | 445 | 157 | ..... | ..... | 31,749 |
| 1906 | ..... | 14,492 | ..... | 93 | ..... | ..... | 14,554 |
| 1907 | ..... | 11,914 | ..... | 83 | ..... | ..... | 11,969 |
| 1908 | ..... | 11,274 | ..... | 66 | ..... | ..... | 11,309 |
| 1909 | 83 | 16,037 | 1,705 | 127 | ..... | ..... | 17,808 |
| 1910 | 93 | 9,588 | 3,433 | 261 | ..... | 2,182 | 13,258 |
| 1911 | 2,306 | 9,860 | 31,547 | 1,254 | 5,587 | ..... | 42,770 |
| 1912 | 3,025 | 8,385 | 27,316 | 634 | 6,243 | ..... | 37,121 |
| 1913 | 3,222 | 4,550 | 15,588 | 254 | 1,147 | 134 | 20,475 |
| 1914 | 2,860 | 4,930 | 63,129 | 577 | 11,083 | 154 | 69,858 |
| 1915 | 2,673 | 2,631 | 350,745 | 2,483 | 14,092 | 787 | 357,138 |
| 1916 | 6,064 | 5,039 | 417,258 | 2,803 | 447 | ..... | 424,251 |
| Increase or decrease, 1916. | +3,391 | +2,048 | +66,513 | +320 | −13,645 | −787 | +67,113 |

[1] For discussion of geology of the districts mentioned in the following pages the reader is referred to Hill, J. M., The mining districts of the Western United States: U. S. Geol. Survey Bull. 507, 1912, and Lindgren, Waldemar, The ore deposits of New Mexico; U. S. Geol. Survey Prof. Paper 68, 1910.

[2] Lee, W. T., The Aztec gold mine, Baldy, N. Mex.: U. S. Geol. Survey Bull. 620, pp. 325–330, 1916.

## DONA ANA COUNTY.

*Mine production in Dona Ana County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ozs.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 5,580 | ..... | 24,101 | 40,000 | 1,581,488 | ..... | $87,145 |
| 1905 | 6,566 | $6,710 | 21,776 | 96,058 | 327,707 | 30,000 | 52,020 |
| 1906 | 16,220 | ..... | 34,051 | 434,000 | 1,207,193 | ..... | 175,386 |
| 1907 | 6,084 | 6 | 25,612 | 776,125 | 675,189 | ..... | 207,920 |
| 1908 | 3,090 | ..... | 9,283 | 21,150 | 379,697 | ..... | 23,660 |
| 1909 | 2,816 | 248 | 16,975 | 10,600 | 772,023 | ..... | 43,650 |
| 1910 | 2 | ..... | 15 | ..... | 705 | ..... | 39 |
| 1911 | 5 | ..... | 111 | 363 | 1,561 | ..... | 173 |
| 1912 | 78 | 17 | 1,790 | 6,685 | 26,129 | ..... | 3,397 |
| 1913 | 155 | 30 | 1,232 | 10,189 | 9,557 | ..... | 2,774 |
| 1914 | 451 | 927 | 3,564 | 78,180 | 29,897 | ..... | 14,462 |
| 1915 | 1,599 | 2,426 | 8,335 | 241,749 | 19,170 | ..... | 49,859 |
| 1916 | 2,615 | 503 | 7,948 | 206,187 | 34,696 | 106,679 | 73,144 |
| Increase or decrease, 1916.. | +1,016 | −1,923 | −387 | −35,562 | +15,526 | +106,679 | +23,285 |

*Organ Mountains district.*—The principal producing mine in this district in 1916 was the Excelsior, from which a considerable quantity of copper ore was shipped. Other producing mines were the Big Three, Black Prince, Memphis, Merrimac, Modoc, and Mormon. The Mormon mine has a 15-ton amalgamation-concentration mill. Several cars of zinc carbonate were shipped from this district. The Phelps Dodge Co., which early in 1916 took options on a large part of this district, including the Bennett-Stephenson, Memphis, and Torpedo groups, says in its annual report for 1916 (dated Feb. 7, 1917):

Active prospecting has been carried on and will be continued during the year. Underground development has on the whole not been discouraging, although no ore has as yet been discovered. The prospecting work as now planned is being confined to the most promising sections and in the future our efforts will be directed to ascertaining if the important veins carry ore in depth.

## GRANT COUNTY.

*Mine production in Grant County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | Placer. | Deep. | | | | | |
| | *Short tons.* | | | *Fine ozs.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 47,032 | $8,081 | $60,347 | 74,793 | 4,428,508 | 179,142 | ..... | $695,099 |
| 1905 | 81,160 | 10,943 | 35,064 | 86,629 | 5,291,222 | 321,035 | 257,203 | 954,026 |
| 1906 | 127,800 | 2,290 | 97,519 | 163,987 | 6,388,830 | 710,895 | 144,656 | 1,492,069 |
| 1907 | 146,746 | 3,782 | 109,260 | 224,279 | 8,046,315 | 1,394,390 | 73,729 | 1,948,582 |
| 1908 | 75,254 | 3,514 | 42,168 | 95,477 | 5,242,767 | 244,589 | 251,070 | 810,403 |
| 1909 | 89,576 | 3,584 | 34,242 | 74,198 | 5,176,585 | 215,070 | 203,278 | 760,590 |
| 1910 | 70,862 | 2,641 | 63,291 | 156,557 | 4,404,394 | 257,953 | 1,285,500 | 790,598 |
| 1911 | 93,770 | 4,043 | 112,241 | 221,882 | 3,918,928 | 694,247 | 306,895 | 772,481 |
| 1912 | 1,200,691 | 2,551 | 163,645 | 356,057 | 32,952,133 | 2,309,732 | 3,135,000 | 6,142,526 |
| 1913 | 1,984,304 | 1,646 | 102,971 | 206,215 | 53,436,177 | 446,805 | 2,553,322 | 8,674,423 |
| 1914 | 1,986,921 | 21,560 | 319,300 | 304,679 | 58,259,113 | 570,513 | (a) | (a) |
| 1915 | 2,523,275 | 1,979 | 363,104 | 508,552 | 72,487,200 | 2,251,383 | (a) | (a) |
| 1916 | 3,577,868 | 2,009 | 417,666 | 549,907 | 87,784,545 | 2,561,638 | (a) | (a) |
| Increase, 1916.... | 1,054,593 | 30 | 54,562 | 41,355 | 15,297,345 | 310,255 | (a) | (a) |

a To avoid disclosing individual production, the zinc production of Grant County is combined with that of Luna County.

*Apache No. 2 (Anderson district).*[1]—An increased tonnage of silver-copper ore with calcite gangue was shipped from the Apache mine in this district.

*Black Hawk district.*—Late in the year 1916 development work was commenced in this old district, long idle, 15 miles west of Silver City, and the Black Hawk mine was unwatered during the early part of 1917.

*Burro Mountain district.*[2]—A large quantity of copper-silver ore was shipped from the Austin-Amazon group. The Burro Mountain Copper Co. commenced in April, 1916, the operation of its 1,000-ton concentration mill, which, after the adjustment period, was operated steadily.

The annual report of Phelps, Dodge & Co. for the calendar year 1916 says of the Burro Mountain Copper Co.:

The gross production of metals contained in concentrates, precipitates, lease ore, and old slag shipped to the Copper Queen Consolidated Mining Co.'s smelter, at Douglas, and in concentrates on hand January 1, 1917, was as follows:

| | Dry weight. | Copper. | Silver. |
|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Ounces.* |
| Concentrates shipped | 25,815 | 7,153,098 | 20,762.82 |
| Concentrates on hand | 646 | 195,170 | ..... |
| Precipitates | 83 | 70,434 | ..... |
| Slag | 1,700 | 91,972 | ..... |
| | 28,244 | 7,510,674 | 20,762.82 |
| Copper from lease ore | ..... | 1,076,724 | ..... |
| Total | ..... | 8,587,398 | ..... |

The net production of copper from ore concentrated was 6,980,855 pounds.

The mine production was 257,501 tons with an average grade of 2.12 per cent copper. Of this amount 245,148 tons were obtained from the mine and 12,353 from the ore dumps.

Favorable developments during the period resulted in a marked increase in the reserves at the end of the year. Our churn-drill operations have given very encouraging results, indicating the existence of good-sized ore bodies in sections of the company's property not otherwise prospected or developed. Of particular interest has been the result of the drilling on the Mohawk and Thistle claims. The known ore bodies have also been considerably extended. * * *

The work of the concentrator is shown in the following summary:

Ore milled, 253,782 tons (dry weight), assaying 2.117 per cent copper.
Concentrates produced, 26,362 tons (dry weight), assaying 13.937 per cent copper.
Tailings produced, 227,420 tons (dry weight), assaying 0.736 per cent copper.
Saving, 68.39 per cent.
Ratio of concentration, 9.627.
Actual running time, 213 days, 9 hours, 25 minutes.
Tons of ore milled per day, actual running time, 1,189.34.
Gallons fresh water used per ton ore milled, 838.15.
Kilowatt hours per ton ore milled, 8.997.

Concentrating operations commenced April 12, and while the average recovery for the year was low, being only 68.39 per cent, the record by months shows this to be due to the crude work done in the first period of operation when conditions were unsettled and numerous adjustments were under way. Constant improvement was made till the month of November when the recovery was 77.16 per cent. While this

[1] As distinguished from Apache (Chloride) district, Sierra County.

[2] Paige, Sidney, Metalliferous ore deposits near the Burro Mountains, Grant County, N. Mex.: U. S. Geol. Survey Bull. 470, pp. 131–150, 1911; U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), 1916. Weed, W. H., The copper mines of the United States in 1905: U. S. Geol. Survey Bull. 285, p. 118, 1906. Somers, R. E., Geology of the Burro Mountains: Am. Inst. Min. Eng. Bull. 101, pp. 957–996, 1915. Bush F. V., Burro Mountain porphyry copper developments: Min. and Sci. Press, Feb. 6, 1915, pp. 222–224.

fell off in December to 76.32 per cent, a considerably larger tonnage was milled. In general, the process which has been adopted as best suited to our ores is a simple one, consisting of table concentration supplemented by flotation for the treatment of slimes. This was developed in the experimental mill and the success thus far attained has justified the delay and cost of thoroughly testing the ore in the small scale plant. No radical changes have been found necessary, the only difficulties encountered being of a mechanical nature in connection with apparatus installed for trial purposes.

There has been added to the mill since operations started additional crushing and regrinding machinery which has increased the capacity from 1,000 tons a day, as originally planned, to 1,400 tons. The advantage of this larger capacity will be reflected in results of the coming year. * * *

Preparation for the systematic leaching of all old partially sulphatized dump ores was completed in December, and from present appearances the treatment which was to a certain extent an experiment will be successful, and further work along similar lines ,with other low-grade ores in this district, will be carried on during the current year.

Lessees on various other properties in this district shipped a considerable quantity of copper-silver ore.

*Central district.*[1]—The output of the Central district, embracing the towns of Bayard, Fierro, Georgetown, Hanover, and Santa Rita, was 3,134,791 tons, yielding $132,962 in gold, 116,953 ounces of silver, 74,228,606 pounds of copper, 2,122,797 pounds of lead, and 7,278,575 pounds of zinc, with a total value of $19,592,956. This district is the most important producing district in New Mexico. Besides the Chino Copper Co.'s mines, at Santa Rita, and the Empire Zinc Co.'s mines, at Hanover, there were 22 other producing mines in the district. Zinc carbonate ore was shipped from the Hanover mines of the Empire Zinc Co., the Mountain Home group, Welsh group, Hanover Copper Co.'s group, and from others. Lessees shipped copper ore from the Copper Queen property at Fierro; copper-lead ore was shipped from the Ground Hog mine; a large quantity of lead ore was shipped from the Lucky Bill mine; copper ore was shipped from the San Jose, at Vanadium; and a large quantity of copper ore and lead ore was shipped from the Ivanhoe mine.

The Empire Zinc Co. also operated its magnetic separating mill [2] at Hanover on zinc sulphide ores from June for the rest of 1916.

The Chino Copper Co. is mining a low-grade copper deposit at Santa Rita by steam shovels. The ore is concentrated at Hurley, where the company's wet-concentration-flotation mill is located. Concentrates and occasional cars of ore are shipped principally to the El Paso smelter. The seventh annual report of the Chino Copper Co., dated April 1, 1917, covering the year ended December 31, 1916, says:

The gross production of copper in concentrates and direct shipments for the year amounted to 75,761,978 pounds. Smelter deductions made the net production 72,319,508 pounds. The gold and silver production realized from the smelter was $80,498. This production of copper and precious metal value was the result of handling during the year 3,094,400 tons of ore.

The net cost of producing copper for the year was 8.706 cents per pound. This was after deducting miscellaneous earnings for the year from the cost of producing copper. This deduction amounted to 0.45 cent per pound.

The net operating profit was $12,517,876; miscellaneous income, dividends, rentals, etc., amounted to $325,286, or a total net profit for the year of $12,843,162, or $14.76 per share, as compared with $7.95 per share for the year 1915, applicable to dividends or for other capital purposes. Dividends aggregating $8.25 per share were paid during

[1] Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), 1916; The Hanover iron-ore deposits, New Mexico: U. S. Geol. Survey Bull. 380, pp. 199–214, 1909. Birkinbine, John, Iron ores of the United States: U. S. Geol. Survey Eighteenth Ann. Rept. pt. 5, pp. 48–50, 1897.

[2] For description see Met. and Chem. Eng., Oct. 10, 1916, pp. 481–482.

the year. * * * After the payment of these dividends aggregating $7,177,335, the surplus amounted to $5,665,827; reserve set aside for depreciation of plant and equipment amounted to $315,214, and the net undivided profits for the year passed to "earned surplus" therefore amounted to $5,350,613. The total "earned surplus" as of December 31, 1916, aggregated $13,963,674. The surplus from the sale of securities over par value remained at the same figure as the previous year, namely, $2,995,252. The total dividends paid up to and including the dividends paid in the year ended December 31, 1916, amounted to $13,875,330. The outstanding stock of the company remained the same, 869,980 shares. * * *

Churn drilling was continued throughout the year, the drills being moved from the Northwest ore body to the Sierra section in order to define the extension of this area to the east and to give data as to the intersection of the stripping slopes between this ore body and the Hearst pit. The total drilling for the year was 13,161 feet. Since the beginning of operations there has been a total of 227,303 feet drilled.

A recalculation of ore reserves as of December 31, 1916, shows the developed ore remaining in and on the property at that time to have been 95,555,843 tons, containing an average of 1.656 per cent copper. Of this quantity, 94,490,936 tons, averaging 1.655 per cent copper, remain unmined. The remainder, amounting to 1,064,907 tons, consists of mixed sulphide and carbonate ore stored in stock piles, and contains an average of 1.81 per cent copper. This ore was so stored because it was not amenable to concentration by the methods regularly employed, but facilities for the treatment of this class of material are now being provided. The total amount of ore that has been developed and reported from time to time since the beginning of operations, including that now reported, is 106,081,263 tons, having an average grade of 1.694 per cent copper. The total of ore mined since mining began amounts to 11,590,327 tons, having an average assay of 2.01 per cent copper. Of this quantity, 10,487,000 tons, averaging 2.02 per cent copper, have been milled, and 22,343 tons, averaging 6.69 per cent copper, have been shipped to the smelter. The remainder represents ore stored in mine stock piles, on hand in coarse crushing plant and mill bins, and in transit between mine and mill. The ore added to reserves as a result of developments for the years 1915 and 1916 averaged 1.35 per cent copper. Of the total ore reserves stated as remaining, it is estimated that 81,765,279 tons will be mined by steam shovels, and 13,790,564 tons by underground mining methods. Since the beginning of operations the tonnage of ore actually milled or shipped direct to the smelter represents 9.92 per cent of the total amount of ore developed, which corresponds to 11.27 per cent of all the ore estimated as being available for steam shovel mining. * * *

In the early part of the year purchase was made of 16 additional 20-yard automatic air dump cars, and later a second unit to the primary crushing plant was authorized and construction begun, in preparation for increased tonnages which the mill is being prepared to accommodate.

The total ore and waste removed by steam shovels during the year was 5,300,891 cubic yards of material in place. Of this amount 3,564,623 cubic yards were stripping, the remainder, equivalent to 3,216,065 tons, being ore. Of the ore that was removed, 3,095,466 tons were shipped to the mill and 646 tons direct to the smelter. The balance was stored on the ore dumps. The ore sent to the storage dumps consisted in part of lower-grade material encountered by the steam shovels at times when the mill was not prepared to receive it, and in part of oxidized ores such as have since the beginning of operations been stored for future treatment.

From the beginning of steam shovel operations on September 23, 1910, there has been removed a total of 22,795,332 cubic yards of material in place, of which 16,886,785 cubic yards were stripping, the remainder being equivalent to 11,586,692 tons of ore. Of this ore, 1,064,907 tons have been stored in the stock piles at the mine. Of the remainder, 10,501,855 tons were shipped to the mill, the balance having been shipped directly to the smelter. The average cost for the steam shovel operations in the removing of both ore and stripping during the year, was 37.97 cents per yard, as against 35.28 cents per yard for the year 1915. This represents an increase equivalent to 7.62 per cent; whereas the increased cost of labor, supplies, and taxes was in terms of percentage several times as great. The cost of handling waste alone was 38.82 cents, an increase of 13.24 per cent, or 4.54 cents per yard, over the cost of 1915. The cost of mining ore was 19.88 cents per ton, this being only 2.1 per cent greater than for 1915. The small advance in the cost of mining ore, notwithstanding the very greatly increased cost of labor and supplies, was due to the greater efficiency of the train service and the benefit of the primary crushing plant. Of the ore production for the year shipped to the mill 5.2 per cent came from the Northwest ore body, 19.7 per cent from the North ore body, 74.5 per cent from the South ore body, and 0.6 per cent from the Southwest ore body.

Following the completion at Hurley of the mill and its accessories, which were originally built for a capacity of 5,000 tons per day, improvements in operating methods were applied from time to time tending principally towards increase of tonnage. During the first half of the year 1914 the plant handled an average of about 6,500 tons per day. Then came the enforced restriction of operations covering a period of several months, during which time only limited expenditures for improvements were made. After full tonnage operations were resumed in 1915 a still more active campaign of betterments was inaugurated, having for its purpose not only the increase of tonnage but the improvement of metallurgy. During the last half of 1915 the plant treated an average tonnage more than 50 per cent in excess of its original capacity. This was made possible by the extension of facilities in the concentrating department, which resulted at the same time in some increase of recoveries. With the beginning of the year 1916 the power requirements of the mill and mine were rapidly approaching the maximum output of the power plant, and it was decided to install an additional turbo generator of a size such as to practically double the safe working capacity of the plant, and thus provide a reserve against possible accident to any of the units. The necessary machinery and accessories were ordered in January of 1916 for delivery in August, but the first of the apparatus was not received until late in the year, and further delays in deliveries will make it impossible to have the full plant in operation much before the middle of 1917. In the meantime further additions and improvements were made in the concentrating department. An entirely new slime settling and water recovery system was designed and is now partially completed. A filter plant was constructed for handling fine slime concentrates, and the original mill was, through all these betterments, brought up to the maximum capacity attainable except by the installation of additional grinding machinery. Throughout the latter half of the year mill operations were hampered not only by the interference of alterations and construction, but by lack of an adequate power supply. Notwithstanding this, the average tonnage for the year 1916 was substantially in excess of that for the period of full capacity operations in 1915. During the first quarter of 1916 it was decided to still further increase the capacity of the plant by the addition of two new sections, thus contemplating the first additions of any consequence to the original mill building. One of these sections and a part of the other will supplement the original mill equipment by an extensive installation of fine grinding machinery as well as additional concentrating machinery for the treatment of the regular class of sulphide concentrating ores. A part of the second section will be set aside for treating the accumulated stock of partially oxidized ores as well as future production of this class of ore until it is exhuasted, after which this section as a whole may be readily converted to the treatment of ores of the normal concentrating variety. Material was not ordered and active construction commenced on the two new sections until late in 1916. At the end of the year the work was well under way, and it is expected that a part of the first new section will be in operation during the second quarter of 1917, but on account of the difficulty in securing construction material it is not probable that the full benefit of the two new sections will be realized much, if any, before the end of the year. It is estimated that the seven-section plant, when completed, will have a capacity of about 12,500 tons per day, corresponding to an increase of about 40 per cent above the capacity of the present five-section plant. About 1,000 tons per day of the increased capacity will be used for the accommodation of partially oxidized or mixed carbonate and sulphide ores. Late in the year 1916 an experimental plant of 100 tons daily capacity was constructed for the purpose of working out improved methods for application to the treatment of all classes of ores. The operation of this plant is affording valuable information from experimental and investigative work without interfering with the tonnage or results of regular milling operations. Investigations covering a period of several months in 1915 and the early part of 1916 indicated that the accumulation of several million tons of mill tailings could be re-treated at a profit. A tailings re-treatment plant of 1,000 tons daily capacity has been constructed and is now practically ready for operation, but cannot be put into commission on account of insufficient power supply pending the completion of power plant improvements. After this tailings plant has been run for a sufficient time to determine the best methods and practicability of tailings re-treatment, it is the intention to increase the capacity of the plant to not less then 5,000 tons per day, thus providing for reworking the accumulation of tailings in about six years. * * *

For the year 1916 there was treated in the mill at Hurley a total of 3,094,400 tons of ore, equivalent to an average of 8,455 tons per day. Previous to June 1 the highest tonnage treated in the mill in any one day was 9,600 tons. In June a maximum of 10,200 tons was attained, after which month the average for periods of several days frequently reached and at times exceeded that figure. This large increase in tonnage was accomplished through changes in the details of milling practice and through mill

improvements which have been in progress for about two years and were still uncompleted at the close of the year. During the last eight months of 1915 the mill averaged 7,865 tons per day; accordingly the increase in capacity for the year 1916 was 14.55 per cent. The improvements introduced during 1915 and 1916 increased the mill's capacity a total of 31.55 per cent over the best former record, which was the first seven months of 1914. This was accomplished in spite of the fact that during the whole year of 1916 the work of construction and alteration interfered considerably with milling operations. The average content of the ore treated for the year was 1.83 per cent copper or 0.32 per cent lower than for 1915. The total production of concentrates was 254,852 tons, which averaged 14.82 per cent copper. The total amount of copper contained in the concentrates was 75,551,376 pounds, corresponding to a recovery of 24.42 pounds of copper per ton of ore and representing an extraction of 66.59 per cent, which was practically the same as that for the year 1915, notwithstanding the increase of tonnage and lower grade of ore. The average milling cost for the year was 64 cents per ton, an increase of 9.81 cents over that for 1915, equivalent to 18.1 per cent, which again is much below the percentage increase of labor, supplies, and taxes.

During the year there was shipped from the mine direct to the smelter 525 dry tons of ore and 122 dry tons of precipitates containing 210,602 pounds of copper.

The production of copper contained in concentrates and other shipping products for the year, by quarters, was as follows:

| | Pounds. |
|---|---|
| First quarter | 16,350,348 |
| Second quarter | 18,157,923 |
| Third quarter | 20,650,761 |
| Fourth quarter | 20,602,946 |
| | 75,761,978 |

The average cost of the stated net copper produced for the year, after making deductions for smelter allowances and after crediting precious metal values and miscellaneous income, was 8.7 cents per pound, as compared to 6.75 cents per pound for the previous year. The credit for precious metals amounted to 0.11 cent per pound, and that for miscellaneous income to 0.45 cent per pound, a total of 0.56 cent per pound. The per pound cost stated includes operating expenses and charges of every nature, except depreciation.

The improvements made during 1916 and the previous year at both mines and mills brought about betterments in operation which are reflected in practically every phase of the foregoing report. The tonnage handled was much larger than that for any previous year; mill recoveries were maintained even in the face of this increased tonnage; and the production for the year was the largest in the history of the company. * * * Betterments now in progress as previously described, which should be practically all completed during the year 1917, will add substantially to the tonnage capacity of the entire property, as well as permit the profitable use of some classes of ores that it has been impossible to commercialize through the use of present equipment and methods. The new tailings re-treatment plant will undoubtedly add substantially to production and profits for a number of years.

*Mine production in Central district, Grant County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 21,048 | $5,582 | 282 | 3,294,308 | 11,977 | ..... | $430,607 |
| 1905 | 17,115 | ..... | ..... | 2,704,233 | ..... | ..... | 421,860 |
| 1906 | 39,155 | 4 | 1,524 | 3,075,001 | 235,070 | 99,656 | 614,648 |
| 1907 | 57,079 | 5,659 | 36,813 | 4,994,575 | 855,358 | 73,729 | 1,078,555 |
| 1908 | 41,852 | 777 | 296 | 3,994,502 | 29,122 | 251,070 | 541,231 |
| 1909 | 41,456 | 816 | 1,380 | 3,348,808 | 23,256 | 203,278 | 448,856 |
| 1910 | 37,008 | ..... | 404 | 2,679,630 | 155 | 1,285,500 | 409,955 |
| 1911 | 45,584 | 104 | 8,673 | 1,413,189 | 605,978 | 290,122 | 325,156 |
| 1912 | 1,136,290 | 998 | 29,586 | 29,512,812 | 2,172,676 | 2,205,824 | 5,138,779 |
| 1913 | 1,948,471 | 9,697 | 12,500 | 51,095,656 | 331,440 | 2,187,266 | 8,167,144 |
| 1914 | 1,934,020 | 102,971 | 42,971 | 55,222,874 | 365,079 | (a) | (a) |
| 1915 | 2,395,795 | 102,379 | 73,267 | 66,581,366 | 1,542,234 | (a) | (a) |
| 1916 | 3,134,791 | 133,962 | 116,953 | 74,228,606 | 2,122,797 | (a) | (a) |
| Increase, 1916 | 738,996 | 31,583 | 43,686 | 7,647,240 | 580,563 | (a) | (a) |

a In order to avoid disclosing individual production, the production of zinc in Central district, Grant County, has been combined with that of Luna County.

*Chloride Flat district (near Silver City).*—No production was made from this district in 1916.

*Eureka district (including Sylvanite).*—A considerable quantity of silver-copper ore was shipped from the copper Dick mine, 12 miles west of Hachita. Other producing mines were the Chappo group, King, Hornet, and Gold Bond.

*Fremont district.*[1]—Development work only was done in this district.

*Gold Hill district.*—The Cline stamp mill continued to yield occasional lots of gold-silver bullion.

*Lordsburg district (including Pyramid and Virginia or Shakespeare districts.*—

The production of this district in 1915 was the largest in its history, but the yield for 1916 was still larger. All the ore was shipped to smelters. The average assay for the district in 1916 was gold, 0.1086 ounce and silver 3.14 ounces per ton, and copper 2 per cent. The principal producing mine was the Eighty-five. Other producing mines were the Battleship, Bonney, Eldorado, Ontario, Nellie Bly, and Robert E. Lee.

*Mine production in Lordsburg district, Grant County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 250 | $1,184 | 2,580 | 18,200 | 12,000 | $5,582 |
| 1905 | 366 | 10 | 7,584 | 48,000 | ..... | 12,079 |
| 1906 | 1,743 | 5,168 | 27,261 | 212,601 | ..... | 64,465 |
| 1907 | 5,645 | 8,761 | 31,303 | 463,335 | 10,522 | 122,646 |
| 1908 | 7,532 | 10,617 | 9,889 | 259,079 | 11,363 | 50,534 |
| 1909 | 10,690 | 25,983 | 50,154 | 589,969 | 8,862 | 129,140 |
| 1910 | 29,220 | 59,796 | 130,324 | 1,627,591 | 19,662 | 337,742 |
| 1911 | 46,139 | 106,648 | 182,448 | 2,455,336 | 2,157 | 510,359 |
| 1912 | 55,340 | 144,859 | 275,251 | 3,155,585 | 4,562 | 835,015 |
| 1913 | 31,284 | 55,234 | 154,779 | 1,601,461 | 14,572 | 397,588 |
| 1914 | 38,964 | 101,080 | 232,647 | 2,614,674 | 30,049 | 578,658 |
| 1915 | 92,093 | 222,848 | 374,325 | 3,890,365 | 28,723 | 1,094,795 |
| 1916 | 118,966 | 267,148 | 373,074 | 4,755,179 | 30,478 | 1,684,508 |
| Increase or decrease, 1916 | +26,873 | +44,300 | −1,251 | +864,814 | +1,755 | +589,713 |

*Pinos Altos district.*[2]—With the exception of zinc, of which there was a greatly increased output, and of a small increase in lead, the production of metals decreased in this district in 1916.

Placer gold in 1916 was credited with $2,009, against $1,979 in 1915. Gold from deep mines in 1916 was credited with $11,775, against $31,823 in 1915.

The principal producing mine in this district was the Empire Zinc Co.'s Cleveland mine, equipped with a magnetic separator mill, which was operated steadily throughout the year. The Pinos Altos Mining & Milling Co.'s 50-ton wet-concentration electrostatic separator was operated for a period on ore from the Langston and Pacific mines. Other important producing mines were the Calumet, Hardscrabble Coat, Manhattan, and Silver Hill.

[1] Darton, N. H., Geology and underground water of Luna County, N. Mex.: U. S. Geol. Survey Bull. 618, pp. 106–107, 1916.

[2] Paige, Sidney, The ore deposits near Pinos Altos, N. Mex.: U. S. Geol. Survey Bull. 470, pp. 109–125, 1911; U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), 1916.

*Mine production in Pinos Altos district, Grant County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | Placer. | Deep. | | | | | |
| | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 4,719 | $7,750 | $49,660 | 37,229 | 104,069 | 2,653 | ..... | $92,587 |
| 1905 | 6,348 | 10,943 | 31,442 | 39,585 | 103,469 | ..... | 160,779 | 82,442 |
| 1906 | 14,074 | 2,290 | 89,674 | 83,566 | 328,788 | ..... | ..... | 211,409 |
| 1907 | 14,841 | 3,782 | 78,723 | 65,862 | 322,195 | ..... | ..... | 190,413 |
| 1908 | 1,451 | 1,479 | 8,548 | 8,941 | 34,514 | 3,953 | ..... | 21,528 |
| 1909 | 38 | 3,584 | 2,083 | 1,377 | 6,200 | 418 | ..... | 7,207 |
| 1910 | 20 | 2,494 | 1,372 | 223 | 269 | 2,226 | ..... | 4,119 |
| 1911 | 355 | 4,043 | 1,406 | 5,616 | 3,232 | 4,063 | 16,773 | 9,968 |
| 1912 | 6,169 | 2,551 | 7,973 | 15,864 | 96,507 | 50,289 | 929,176 | 102,581 |
| 1913 | 3,643 | 1,646 | 29,162 | 28,276 | 100,555 | 83,067 | 366,056 | 87,626 |
| 1914 | 3,686 | [a] 21,650 | 114,181 | 23,256 | 129,587 | 29,994 | 48,840 | 169,497 |
| 1915 | 7,024 | 1,979 | 31,823 | 19,856 | 377,463 | 130,638 | (b) | (b) |
| 1916 | 46,471 | 2,009 | 11,775 | 17,816 | 122,716 | 152,696 | (b) | (b) |
| Increase or decrease, 1916 | +39,447 | +30 | −20,048 | −2,040 | −254,747 | +22,058 | (b) | (b) |

[a] Placer and surface lode mines combined. Only small quantity recovered by actual placer methods. Fineness so similar, separation not practicable.

[b] In order to avoid disclosing individual production, the production of zinc in Pinos Altos district, Grant County, has been combined with that of Luna County.

*San Simon (Granite Gap) Steins district.*—Producing mines in this district, with chief output in silver, but some gold, copper, and lead, were the Granite Gap, Wasp & Fly, and Stockton mines.

*Steeplerock district.*—At the Carlisle mine, long idle, opened by a 500-foot shaft and a winze to 637 feet and with drifts approximating 7,500 feet, the water was pumped from the property, and a 100-ton test-flotation wet-concentration mill was installed. Small lots of lead-zinc ore were shipped for test purposes. Small shipments were also made from the Shamrock, Twin Peaks, and Jim Crow mines.

*Steins Pass (Kimball) district.*—Copper-silver ore was shipped from the Copper King, Copper Queen, and Johnny Bull mines, and lead-silver ore from the Oldan mine.

*Swarts (Carpenter) district.*—Several cars of lead and lead-zinc sulphide ore were shipped from the Grand Central mine in this district.

*White Signal (Cow Springs) district (Whitewater).*—Several small lots of copper ore were shipped from the Calamity, Christmas Gift, and Eugenia mines.

## GUADALUPE COUNTY.

A car of copper ore was shipped from the Pintado mine in the Pintado district. It is reported that a leaching plant is to be built here.

## LINCOLN COUNTY.

*Mine production in Lincoln County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | Placer. | Deep. | | | | |
| | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 820 | $20,100 | $8,496 | 2,576 | ..... | 2,261 | $30,183 |
| 1905 | 3,060 | 2,260 | 5,215 | 757 | 14,404 | 7,511 | 10,532 |
| 1906 | 6,380 | ..... | 16,463 | 1,946 | ..... | ..... | 17,767 |
| 1907 | 5,767 | ..... | 41,417 | 721 | ..... | ..... | 41,893 |
| 1908 | 4,399 | 816 | 28,396 | 5,472 | 1,195 | ..... | 32,770 |
| 1909 | 3,633 | 472 | 23,391 | 388 | 700 | 7,977 | 24,499 |
| 1910 | 10,727 | 1,400 | 53,876 | 559 | 189 | 5,614 | 55,849 |
| 1911 | 1,578 | 1,629 | 30,305 | 184 | 555 | 6,620 | 32,399 |
| 1912 | 2,003 | 1,008 | 21,408 | 1,005 | 9,988 | 103,911 | 29,358 |
| 1913 | 5,589 | 1,027 | 41,469 | 1,100 | 7,068 | 94,010 | 48,392 |
| 1914 | 13,540 | 908 | 62,499 | 961 | 15,068 | 10,641 | 66,360 |
| 1915 | 8,550 | 1,308 | 44,068 | 493 | 5,091 | 13,277 | 47,141 |
| 1916 | 1,490 | 651 | 7,093 | 953 | 28,045 | ..... | 15,270 |
| Increase or decrease, 1916... | −7,060 | −657 | −36,975 | +460 | +22,954 | −13,277 | −31,871 |

*Estey district (Oscuro Mountains).*—Several cars of copper-silver ore were shipped from the Estey City, Roberts, and Tillman properties.

*Gallinas district.*—No shipments were made in 1916.

*Jicarilla district.*—Small placers in this district yielded $651 in gold as against $1,308 in 1915.

*Nogal district.*—A car of copper ore was shipped from this district. The 250-ton cyanidation plant of the Parsons Mining Co., construction of which was begun in 1915, was completed early in 1917. This company will operate the Hopeful mine by open cuts.

*Whiteoaks district.*—During a part of the year the Homestake amalgamation mill was operated on ore from the North Homestake and South Homestake mines.

## LUNA COUNTY.

*Mine production in Luna County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 1,576 | $1,695 | 8,549 | 16,000 | 671,772 | ..... | $37,605 |
| 1905 | 1,346 | ..... | 5,199 | ..... | 463,956 | 225,000 | 38,221 |
| 1906 | 1,994 | 413 | 11,265 | ..... | 831,193 | 103,836 | 61,673 |
| 1907 | 2,048 | 13,741 | 8,633 | ..... | 1,022,773 | ..... | 73,646 |
| 1908 | 288 | 3 | 1,077 | 5,934 | 127,535 | ..... | 6,713 |
| 1909 | 1,163 | 3,208 | 6,916 | 1,115 | 682,906 | ..... | 36,314 |
| 1910 | 525 | 26 | 2,484 | 47 | 298,112 | ..... | 14,490 |
| 1911 | 229 | 104 | 1,278 | 1,814 | 98,888 | ..... | 5,458 |
| 1912 | 3,090 | 5,687 | 24,265 | ..... | 827,556 | 458,594 | 89,493 |
| 1913 | 5,185 | 11,085 | 41,664 | 1,453 | 1,158,682 | 702,028 | 126,771 |
| 1914 | 2,127 | 226 | 2,975 | 2,181 | 416,923 | (a) | (a) |
| 1915 | 2,082 | 491 | 2,795 | 4,080 | 148,766 | (a) | (a) |
| 1916 | 7,630 | 3,535 | 18,077 | 2,663 | 868,724 | (a) | (a) |
| Increase or decrease, 1916 | +5,548 | +3,044 | +15,282 | −1,417 | +719,958 | (a) | (a) |

[a] In order not to disclose individual production, the production of zinc from Luna County in 1916 is included with that of Grant County.

*Cooks Peak district.*[1]—The ores of this district are lead carbonate and zinc carbonate and sulphide. Mines from which ore was shipped

[a] Darton, N. H., Geology and underground water of Luna County, N. Mex.: U. S. Geol. Survey Bull. 618, pp. 102–103, 1916.

in 1916 were the Desdemona-Othello-Monte Christo group, Summit-Grand Central group, Faywood, Saddler & Tuckwood.

*Florida Mountain district.*[1]—A large quantity of zinc ore was shipped from the Lucky John mine and from the Raithel property, in the Florida Mountains.

*Tres Hermanas district.*[2]—A large quantity of lead carbonate and zinc carbonate ore was shipped from this district in 1916. Producing mines were the Bull Dog, Contention, Mahoney, and Winnie mines.

*Victorio (Gage) district.*[3]—The year 1916 saw a revival in mining activity in this district, and a considerable quantity of silver-lead ore was shipped to smelters. Producing mines were the Rambler and the Chance group.

## OTERO COUNTY.

*Mine production in Otero County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | Placer. | Deep. | | | | |
| | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 170 | $1,050 | $1,569 | 164 | 14,400 | ..... | $4,586 |
| 1905 | 117 | 1,036 | 41 | 93 | 53,602 | ..... | 9,495 |
| 1906 | 268 | 195 | 228 | 533 | 133,166 | ..... | 26,481 |
| 1907 | 12,203 | 100 | 14,711 | 2,135 | 679,480 | ..... | 152,116 |
| 1908 | 22,418 | 1,475 | 34,215 | 4,351 | 723,907 | ..... | 133,552 |
| 1909 | 143 | 100 | 157 | 29 | 6,354 | ..... | 1,098 |
| 1910 | 2,545 | 6,022 | 2,559 | 2,046 | 49,874 | 6,046 | 16,286 |
| 1911 | 1,096 | ..... | 6,718 | 715 | 22,730 | 739 | 9,971 |
| 1912 | 3,792 | 2,034 | 11,005 | 1,107 | 146,588 | ..... | 37,907 |
| 1913 | 25,582 | 42 | 49,830 | 7,088 | 760,914 | 1,911 | 172,179 |
| 1914 | 11,176 | ..... | 38,515 | 5,761 | 418,316 | 2,027 | 97,416 |
| 1915 | 16,628 | ..... | 54,979 | 6,255 | 872,748 | ..... | 210,881 |
| 1916 | 21,838 | 305 | 39,525 | 7,928 | 1,166,972 | 17,392 | 333,321 |
| Increase or decrease, 1916... | +5,210 | +305 | −15,454 | +1,673 | +294,224 | +17,392 | +122,440 |

*Highrolls (Sacramento) district.*—Shipments of ore from this district in 1916 were the largest on record. No one mine shipped many cars, but 9 mines in all each shipped a car or more of silver-copper ore. The principal producing mines were the Courtney, Stockman, Canon, La Luz, Alamo, and Roughrider.

*Jarilla (Orogrande, Silver Hill, Brice) district.*—Lode mines in this district in 1916 produced 20,195 tons of ore yielding $39,504 in gold, 7,401 ounces of silver, 1,077,492 pounds of copper, and 638 pounds of lead, with a total value of $309,481. This is the largest production at least since 1904, when the Geological Survey records begin. There was also a small yield from the Little Joe-Cashins group placer property, the gravel of which is treated in a small amalgamation-concentration mill. Producing deep mines were the By Chance, Delusion, Fannie, Garnet, Gem, Lincoln, Lucky, Mexican, Mispah, Nannie Baird, and Turquoise. All the ore was shipped to smelters. In addition, considerable magnetite iron ore was shipped to the Colorado Fuel & Iron Co.'s steel mill, at Pueblo, Colo.

*Tularosa district.*—Several cars of copper ore were shipped from this district, and also a car of copper concentrates obtained by the

[1] Darton, N. H., op. cit., pp. 107–108.
[2] Lindgren, Waldemar, The Tres Hermanas mining district, N. Mex.: U. S. Geol. Survey Bull., 380, pp. 123–128, 1909. Darton, N. H., op. cit., pp. 105–106.
[3] Darton, N. H., op. cit., pp. 103–104.

milling of ore from the Virginia mine at the 50-ton concentration mill on the property.

### RIO ARRIBA COUNTY.

*Bromide (Tusas) district.*—A car of silver-copper ore was shipped from the Bromide mine.

From the B. & M. group and from the Wayman mine (exact locality of both unknown) was shipped a car of copper ore.

### SANDOVAL COUNTY.

*Cochiti (Bland district).*—The Cossak 100-ton continuous counter-current decantation-cyanidation mill, closed in November, 1915, was again placed in operation in April, 1916, and was operated until October. The product is silver-gold bullion.

*Nacimiento Mountains district.*—Several cars of silver-copper ore were shipped to El Paso from the San Miguel mines, near Senorito, in the "Red Beds." There is a 12-ton reverberatory furnace in the district, and it is proposed to erect a leaching plant.

*Gallina-Jarossa district.*—A car of copper-silver ore was shipped from the Pay lode, in the Jarossa district.

### SANTA FE COUNTY.

*Mine production in Santa Fe County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | Placer. | Deep. | | | | | |
| | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 170 | $4,135 | $1,292 | ..... | 2,308 | ..... | ..... | $5,727 |
| 1905 | 180 | 4,002 | 2,241 | 42 | ..... | ..... | ..... | 2,266 |
| 1906 | 128 | 6,737 | 7,143 | 53 | ..... | ..... | ..... | 13,916 |
| 1907 | 21,338 | 1,231 | 16,748 | 17,635 | 1,231,260 | ..... | ..... | 275,870 |
| 1908 | 7 | 1,789 | 242 | 6 | ..... | ..... | ..... | 2,034 |
| 1909 | 2,831 | 1,817 | 871 | 2,295 | 1,093 | 213,558 | 4,426 | 13,445 |
| 1910 | 4,739 | 4,262 | 3,877 | 3,359 | 5,150 | 262,023 | 74,759 | 26,173 |
| 1911 | 120 | 2,359 | 1,325 | 2,632 | 16,644 | 11,178 | ..... | 7,663 |
| 1912 | 15,335 | 1,302 | 10,216 | 14,178 | 810,563 | 12,511 | 10,565 | 155,272 |
| 1913 | 29,800 | 129 | 26,076 | 22,076 | 1,798,769 | 794 | ..... | 319,053 |
| 1914 | 23,584 | 1,312 | 9,040 | 5,723 | 293,360 | 52,948 | 89,860 | 59,182 |
| 1915 | 27,713 | 1,567 | 42,100 | 24,371 | 1,704,857 | 50,638 | 14,556 | 358,558 |
| 1916 | 42,683 | 3,112 | 66,254 | 31,871 | 2,153,610 | 166,304 | 334,321 | 676,399 |
| Increase, 1916 | 14,970 | 1,545 | 24,154 | 7,500 | 448,753 | 115,666 | 319,765 | 317,841 |

*Cerrillos district.*—The concentration mill at the Grand Central mine was operated during the year with a product of lead, zinc, and lead-zinc concentrates. The 100-ton concentrating mill of the Tom Payne mine was also operated, the product being lead and zinc concentrates.

*New Placers and San Pedro districts.*—The mines and 125-ton matting plant of the Santa Fe Gold & Copper Co. were operated continuously throughout the year. Several cars of copper ore were shipped to El Paso from prospects in the San Pedro region.

The Santa Fe Dredging Co., operating gravels near Golden with a traction dredge for 40 days, produced an appreciable quantity of

gold bullion, averaging 0.932 fineness gold and 0.054 fineness silver. There were several small lots of placer gold from this district during the year from small panning operations.

## SIERRA COUNTY.

*Mine production in Sierra County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | Placer. | Deep. | | | | | |
| | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 1,295 | $22,979 | $51,617 | 17,055 | 16,700 | ..... | ..... | $86,632 |
| 1905 | 3,516 | 47,878 | 51,164 | 8,700 | 46,664 | ..... | ..... | 11,613 |
| 1906 | 3,246 | 1,509 | 16,539 | 8,102 | 5,995 | ..... | ..... | 24,633 |
| 1907 | 700 | 595 | 7,629 | 2,250 | 5,425 | 9,548 | ..... | 11,300 |
| 1908 | 680 | 1,979 | 16,039 | 8,589 | 12,874 | 6,075 | ..... | 24,524 |
| 1909 | 4,294 | ..... | 10,450 | 25,608 | 25,838 | 49,023 | ..... | 29,280 |
| 1910 | 8,306 | 584 | 11,113 | 15,778 | 2,448 | 11,274 | ..... | 21,024 |
| 1911 | 5,036 | 823 | 26,962 | 16,487 | 5,374 | 28,088 | ..... | 38,459 |
| 1912 | 252 | 1,546 | 2,597 | 11,236 | 8,988 | 21,001 | ..... | 13,481 |
| 1913 | 269 | 423 | 434 | 2,529 | 2,568 | 32,685 | ..... | 4,221 |
| 1914 | 98 | 442 | 1,305 | 3,962 | 14,436 | 5,743 | ..... | 6,093 |
| 1915 | 438 | 1,757 | 1,079 | 316 | 2,228 | 24,617 | 7,492 | 5,472 |
| 1916 | 935 | ..... | 1,468 | 2,138 | 14,427 | 126,609 | 7,045 | 16,104 |
| Increase or decrease, 1916 | +497 | −1,757 | +389 | +1,822 | +12,199 | +101,992 | −447 | +10,632 |

*Caballos Mountains district.*[1]—Lessees operating the Marion mine shipped a large quantity of lead ore to El Paso.

*Chloride (Apache, Cuchillo Negro) district.*—A small shipment of copper ore was made from the Enterprise mine.

*Hermosa district.*—A small lot of copper ore was shipped from the Flagstaff mine. A car each of silver-lead ore and zinc carbonate ore was shipped from the Wolford mine.

*Hillsboro (Las Animas) district.*—Several small lots of gold-silver-copper ore was shipped from this district. Producing mines were the Garfield, Butler, Gold Bell, Santa Rita-Sherman, and Wicks Gulch. Development work was done at the old El Oro mine, now called the Las Animas.

*Kingston (Black Range) district.*—A small shipment of copper ore was made from the Teddy Bear mine.

*Lake Valley district.*[2]—Some development was done in this district, once famous, but idle since 1894.

*Tierra Blanca (Bromide No. 1) district.*—Several cars of lead-copper ore were shipped from the Tom Casey mine during the year. Development work was done on the Midnight group, from which no production has been made since 1902.

[1] Hess, F. L., Vanadium in the Sierra de los Caballos, N. Mex.: U. S. Geol. Survey Bull. 530, pp. 157–160, 1912.

[2] Clark, Ellis, The silver mines of Lake Valley, N. Mex.: Am. Inst. Min. Eng. Trans., vol. 24, pp. 138–167, 1894.

## SOCORRO COUNTY.

*Mine production in Socorro County, N. Mex., 1911–1916.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. |
| | *Fine ounces.* | | *Fine ounces.* | |
| 1911 | 25,844.49 | $534,253 | 1,109,945 | $588,271 |
| 1912 | 25,427.30 | 525,629 | 1,126,439 | 692,754 |
| 1913 | 30,179.04 | 623,856 | 1,347,160 | 813,685 |
| 1914 | 30,542.38 | 631,367 | 1,424,763 | 787,893 |
| 1915 | 24,654.47 | 509,653 | 1,358,000 | 688,506 |
| 1916 | 18,146.67 | 375,125 | 1,081,711 | 711,766 |
| Increase or decrease, 1916 | −6,507.80 | −134,528 | −276,289 | +23,260 |

| Year. | Copper. | | Lead. | | Zinc. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| 1911 | 79,321 | $9,915 | 2,124,901 | $95,621 | 9,930,281 | $566,026 | $1,794,086 |
| 1912 | 89,776 | 14,813 | 2,193,178 | 98,693 | 9,962,478 | 687,411 | 2,019,300 |
| 1913 | 289,566 | 44,883 | 2,199,247 | 96,767 | 13,267,811 | 742,997 | 2,322,188 |
| 1914 | 214,722 | 28,588 | 674,795 | 26,317 | 13,785,176 | 703,044 | 2,177,179 |
| 1915 | 1,416,098 | 247,817 | 2,033,723 | 95,585 | 18,437,218 | 2,286,215 | 3,827,776 |
| 1916 | 1,013,264 | 249,263 | 4,424,522 | 305,292 | 19,312,179 | 2,587,832 | 4,229,278 |
| Increase or decrease, 1916 | −402,834 | +1,446 | +2,390,799 | +209,707 | +874,961 | +301,617 | +401,502 |

*Magdalena (Kelly) district.*—The principal metal produced in this district is zinc, and for 1916 the yield of that metal increased from 18,437,218 pounds, valued at $2,286,215, to 19,312,179 pounds, valued at $2,587,832. The yield of lead also increased from 2,031,297 pounds in 1915 to 4,421,290 pounds in 1916.

The 150-ton flotation (nonfroth) mill, of the Ozark Smelting & Milling Co.[1] was operated continuously on zinc sulphide ore from the Graphic and Waldo mines, with product of zinc concentrate, until August 10, 1916, when the mill was destroyed by fire. Reconstruction was started very shortly afterward and it is planned to resume operations in April, 1917. The Kelly magnetic separation mill was also operated on zinc-lead sulphide ores from the Kelly mine. From the Graphic-Waldo property was also shipped large quantities of copper sulphide, lead oxidized, zinc-lead sulphide, zinc oxidized, lead-copper sulphide, copper oxidized, and lead-zinc sulphide slimes from the old mill. Zinc and lead oxidized ores were shipped from the Germany mine and also from the Ambrosia-Juniata property. Zinc and copper sulphide ores were shipped from the Hardscrabble mine. A 40-ton concentration mill was built at the Black Cloud mine and operations began in September.

[1] For description see Min. and Sci. Press, Jan. 22, 1916, pp. 128–130.

*Mine production in Magdalena district, Socorro County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1904 | 27,998 | $154 | 5,024 | 3,200 | 688,209 | 17,991,780 | $932,658 |
| 1905 | 30,411 | ..... | 4,800 | 320,000 | 390,000 | 14,630,051 | 934,322 |
| 1906 | 35,478 | ..... | 2,515 | 64,560 | 238,088 | 17,044,163 | 1,067,410 |
| 1907 | 3,630 | 13 | 4,406 | 24,045 | 707,981 | 676,356 | 85,158 |
| 1908 | 6,319 | 72 | 460 | 2,605 | 16,073 | 3,325,446 | 157,631 |
| 1909 | 30,724 | 435 | 17,925 | 170,792 | 3,065,279 | 12,878,241 | 860,051 |
| 1910 | 42,232 | 468 | 65,800 | 152,181 | 3,451,228 | 16,727,870 | 1,110,529 |
| 1911 | 25,840 | 352 | 42,773 | 77,448 | 2,123,039 | 9,930,281 | 694,266 |
| 1912 | 22,500 | 746 | 32,792 | 69,532 | 2,192,792 | 9,962,478 | 818,473 |
| 1913 | 47,647 | 3,942 | 40,212 | 278,252 | 2,198,030 | 13,267,311 | 911,060 |
| 1914 | 51,595 | 2,265 | 14,436 | 214,722 | 674,205 | 13,785,176 | 768,144 |
| 1915 | 75,401 | 488 | 56,897 | 1,406,789 | 2,031,297 | 18,437,218 | 2,657,209 |
| 1916 | 78,669 | 2,036 | 72,877 | 993,199 | 4,421,290 | 19,312,179 | 3,187,217 |
| Increase or decrease, 1916... | +3,268 | +1,548 | +15,980 | −413,590 | +2,389,993 | +874,961 | +830,008 |

*Mogollon (Cooney) district.*—This district continued to be the most important silver-producing district in New Mexico, but the decreased gold output placed the district second in rank to the Baldy district, Colfax County. The silver output represented 57 per cent of the State yield and the gold 27 per cent of the total output of gold.

The Mogollon Mines Co.'s mill was operated continuously on company ore only, and 2,290 feet of development work was done at the mine. The Fanney mill was operated steadily on company and custom ore. The Oaks Co. did development work at the Eberle-Clifton mines and sold such ore as came from development work to the Fanney mill. Several lots of ore were also shipped from the Golden Eagle mine.

*Mine production in Mogollon or Cooney district, Socorro County, N. Mex., 1904–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 11,276 | $61,880 | 79,014 | 422,308 | ..... | $162,484 |
| 1905 | 15,534 | 97,158 | 240,943 | 295,175 | ..... | 288,735 |
| 1906 | 16,076 | 127,907 | 268,567 | ..... | ..... | 307,847 |
| 1907 | 20,698 | 105,413 | 418,338 | 150,000 | ..... | 411,516 |
| 1908 | 19,546 | 116,418 | 278,939 | ..... | ..... | 264,256 |
| 1909 | 23,945 | 111,464 | 249,413 | 46 | 49 | 241,167 |
| 1910 | 50,514 | 304,210 | 595,669 | ..... | ..... | 625,871 |
| 1911 | 102,219 | 531,358 | 1,067,038 | 1,873 | 1,862 | 1,097,206 |
| 1912 | 101,361 | 524,858 | 1,093,158 | 184 | 386 | 1,197,197 |
| 1913 | 115,739 | 619,886 | 1,306,766 | 4,418 | 1,217 | 1,409,912 |
| 1914 | 136,124 | 629,102 | 1,410,327 | ..... | 590 | 1,409,035 |
| 1915 | 119,710 | 509,165 | 1,301,059 | ..... | 2,426 | 1,168,916 |
| 1916 | 118,257 | 373,068 | 1,008,483 | 858 | 3,232 | 1,037,084 |
| Increase or decrease, 1916..... | −1,453 | −136,097 | −292,576 | +858 | +806 | −131,832 |

*San Andres and Oscuro mountains.*—Several cars of copper ore were shipped from properties in the Oscuro Mountains and the San Andres Mountains, southeast of Carthage.

### TAOS COUNTY.

*Copper Mountain (Picuris) district.*—Copper ore was milled at the 25-ton concentration mill of the Champion property, between Renasco and Dixon. Some ore was also shipped direct to the smelter at Pueblo from this property and also from the Isabella mine near-by.

*Red River district.*—Development work only was done in this district.

*Rio Hondo district.*—Some development work was done in this district.

### TORRANCE AND VALENCIA COUNTIES.

*Carocito district.*[1]—From several prospects north of Scholle and west of Mountainair, on the Atchison, Topeka & Santa Fe Railway, were shipped 3,172 tons of copper ore carrying 2,600 ounces of silver and 331,475 pounds of copper. According to Charles T. Kirk,[2] State geologist of New Mexico, Albuquerque, N. Mex., the ores are mainly of the bedded type and occur in the "Red Beds." The ore lies nearly altogether in limestone and shaly limestone and the minerals are chalcocite, malachite, and azurite.

[1] See Min. and Sci. Press, Sept. 2, 1916, p. 366.
[2] Personal communication.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN TEXAS.[1]

(MINES REPORT.)

By CHARLES W. HENDERSON.

## PRODUCTION.

The total value of the production of gold, silver, copper, lead, and zinc in Texas in 1916 was $489,466, the largest since the beginning of the mining industry of the State in 1884. Silver remained the principal metal, with a slightly reduced yield in quantity but a very appreciable increase in value. The greater part continued to come from the Presidio silver mine and cyanidation mill, in the Shafter district, Presidio County. From the same district a considerable quantity of zinc carbonate ore was shipped from the Chinatti mine. Several cars of silver-lead-gold ore were shipped from the Last Chance mine.

A car of lead-silver ore was shipped from the Alpine district, Brewster County; a considerable quantity of silver-copper ore was shipped from the Allamoore district, Culberson County; copper-lead-silver-gold ore was shipped from the Sierra Blanca district, El Paso County; and several cars of copper (nodules of chalcocite in clay) ore were shipped from Crowell (Foard County) and Truscott (Knox County).

*Mine production of gold, silver, copper, lead, and zinc in Texas, 1885–1916.*[a]

| Period. | Gold. | Silver. | | Copper. | | Lead. | | Zinc. | | Total value (commercial). |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Quantity. | Commercial value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | | *Fine oz.* | | *Pounds* | | *Pounds.* | | *Pounds.* | | |
| 1885–1890 | $6,906 | 1,670,720 | $1,652,225 | ..... | ..... | ..... | ..... | ..... | ..... | $1,659,131 |
| 1891–1900 | 30,682 | 4,332,214 | 2,979,288 | 42,000 | $5,376 | 7,385 | $318 | ..... | ..... | 3,015,664 |
| 1901–1910 | 3,372 | 3,950,644 | 2,266,537 | 35,383 | 4,647 | 295,018 | 13,611 | 95,957 | $5,262 | 2,293,429 |
| 1911 | 21 | 424,394 | 224,929 | ..... | ..... | 122,800 | 5,526 | ..... | ..... | 230,476 |
| 1912 | 63 | 406,067 | 249,731 | 721 | 119 | 65,311 | 2,939 | 238,000 | 16,422 | 269,274 |
| 1913 | 340 | 427,553 | 258,242 | 34,665 | 5,373 | 225,227 | 9,910 | 652,607 | 36,546 | 310,411 |
| 1914 | 234 | 530,817 | 293,542 | 23,760 | 3,160 | 149,027 | 5,812 | 216,451 | 11,039 | 313,787 |
| 1915 | 1,503 | 675,473 | 342,465 | 42,491 | 7,436 | 219,298 | 10,307 | 30,395 | 3,769 | 365,480 |
| 1916 | 414 | 653,455 | 429,973 | 99,569 | 24,494 | 49,927 | 3,445 | 232,388 | 31,140 | 489,466 |
| | 43,535 | 13,071,337 | 8,696,932 | 278,589 | 50,605 | 1,133,993 | 51,868 | 1,465,798 | 104,178 | 8,947,118 |
| Increase or decrease, 1916 | −1,089 | −22,018 | +87,508 | +57,078 | +17,058 | −169,371 | −6,862 | +201,993 | +27,371 | +123,986 |

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 236, 1915.

[1] For discussion of the geology of the districts mentioned in the following pages the reader is directed to the bibliography in Mineral Resources, 1912, pt. 1, pp. 876–877, 1913; to Survey Bulletin 507; The mining districts of the western United States, by J. M. Hill, with a geologic introduction by Waldemar Lindgren, 1912; and to Mineral Resources, 1908, pt. 1, pp. 539–540, 1909.

## REDUCTION MILLS.

Mineral Resources for 1912, Part I, page 879, contained a complete list of the reduction mills in Texas in 1912, with description of equipment and process. Any changes in this list for 1916 have been noted in the text for the several counties, and reference shouid be made to the 1912 report for details of equipment.

## REVIEW BY COUNTIES.[1]

### BREWSTER COUNTY.

A car of silver-lead ore was shipped from the Alpine district. In this district is the Bird mine, from which, in the past, some silver-bearing galena has been shipped to the El Paso smelter.[2] Development work was begun at the Bird mine early in 1917.

### BURNET COUNTY.[3]

No work seems to have been done in the district northwest of Burnet.

### CULBERSON COUNTY.[3]

The mining districts of Culberson County were included in El Paso County before 1911. An increased tonnage of silver-copper ore was shipped from the Allamoore district, principally from the Hazel mine, in pre-Cambrian sandstone.[4]

### EL PASO COUNTY.

A shipment of silver-copper ore was made from the Little Lightning mine in the Sierra Blanca district.

### FOARD AND KNOX COUNTIES.

A car of copper ore from Crowell, Foard County, and several cars of copper ore from Truscott, Knox County, from the blue clays of the Permian beds[5] were shipped during 1916. Other shipments were made early in 1917.

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[1] In this section references to discussions of the geology of the several districts are given in the footnotes.
[2] Phillips, W. B., Lead ore in Burnet County, Tex.: Eng. and Min. Jour., vol. 77, p. 364, 1904.
[3] Richardson, G. B., U. S. Geol. Survey Geol. Atlas, Van Horn folio (No. 194), 1913.
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## LLANO COUNTY.[1]

Mining for gold ore at the Heath mine[2] was abandoned in 1916 and the cyanidation mill was converted into a graphite reduction plant. Manganese ore was shipped from this district.

## PRESIDIO COUNTY.

*Shafter district.*[3]—Operations were continuous at the Presidio mine, from which the greater part of the silver output of the State has come since 1884. The ore, which is chiefly silver chloride (horn silver), with which are associated more or less isolated patches of silver-bearing galena, was treated from 1884 to 1913 by pan amalgamation; but in May, 1913, the mill was reconstructed into a 125-ton cyanidation plant, using the all-sliming process and continuous agitation and filtration. Several cars of lead ore were shipped from the Last Chance mine. A considerable quantity of zinc carbonate ore from the Chinatti mine was shipped, which appears to have been idle since 1890, when a car of silver-lead-gold ore was shipped.

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# GOLD, SILVER, COPPER, LEAD, AND ZINC IN CALIFORNIA.

(MINES REPORT.)

By CHARLES G. YALE.

## INTRODUCTION.

The most notable features in the conditions of the metal-mining industry in California in 1916 were the very material increase in value of total output, amounting to more than $7,000,000; the increase in quantity of ore from the deep mines; the increase in average value of the ore mined and treated; the decrease in output of gold; the augmented yield and value of other metals; and the lack of skilled labor in the gold fields of the State.

As California has the record of having been by far the largest producer of gold among the States in the Union and of still maintaining that lead in the annual output of this metal, it is proper to consider the conditions in the California gold-mining industry.

The deep gold mines, which usually produce about 62 to 64 per cent of the annual total output of gold in the State, yielded only about 60 per cent in 1916. This result was due to several causes, none of them, however, bearing on the actual possible productivity of the mines themselves. The main reason was that labor strikes in the Mother Lode section of the State restricted ore production more or less for nearly two months in 1916 and caused the hanging up of all or part of the stamps in the mills of many of the larger producing mines in the State. Moreover, as the copper mines of the West offered a bonus over day wages, based on the price of copper, and mines in adjoining States raised the rate of miners' wages above that prevailing in California, a great many miners left the State. The best machine men, such as those running the drills, went to munition factories in the East and elsewhere, and the best timber men also sought other places for employment, lured by higher wages. These conditions left the larger deep mines of the State short of skilled labor. In general the cost of gold mining in both labor and supplies was greatly increased, so much so that several deep mines were entirely closed down and others curtailed operations materially. The Federal commission having control of the hydraulic mines in the drainage basins of the Sacramento and the San Joaquin, where navigable streams are, or may be, damaged by débris resulting from mining operations, have extended their supervision more strictly than formerly to deep mines also. The larger of these mines are now compelled

to impound their mill tailings to prevent them from entering the streams, and this has entailed considerable expense in the construction of impounding dams and in purchase of land for storage of tailings.

There is much complaint on the part of mine operators over this Federal supervision and control as at present enforced. The owner of the most productive deep gold mine in the State, however, is of the opinion that if the Government had enforced this impounding of mill tailings 25 years ago it would have meant millions of dollars profit to the owners of deep mines, as these tailings, all carrying more or less gold and for years allowed to go to waste, could now be cyanided with great profit had they been stored as they must be at present.

The flotation process is growing in favor and a number of plants have been put in, especially at certain prominent copper mines. There was no extension in the use of the cyanide process in 1916, owing to the high cost of cyanide; several proposed plants were given up; and at some smaller mines the use of the process was discontinued.

In several counties of the State there was large increase in total output in 1916, but in almost every case the increase was due to the yield of copper rather than of gold. Some deep gold mines which have been largely productive for years were closed. To offset this, however, a much greater number of old mines which have been idle for years were reopened, and after being suitably equipped will add to the output of gold in 1917. Two of the largest and most productive of the deep gold mines of the State now have their main shafts sunk below the 4,000-foot vertical depth and are encouraged to still deeper sinking by finding good bodies of profitable ore at the depths attained. Quartz mill construction was not very active in California in 1916, but several new mills were erected and others were enlarged.

The gold-dredging industry in the State has not shown any signs of decrease in importance, notwithstanding the reduction in yield in the Oroville and Folsom fields. The Yuba County field is increasing in importance and more than makes up any deficiency in the other two large dredging fields. Moreover, the smaller dredging fields show some increase in output, particularly in Eldorado, Shasta, Siskiyou, and Trinity counties. In these so-called "outside" districts some new dredges have been constructed and some old ones from Oroville and elsewhere have been moved to new locations.

The output of ore from the deep mines of the State was larger in 1916 by 184,863 tons than in 1915 and considerably larger than in 1909, heretofore the "banner" year; moreover the average value per ton rose from $7.87 in 1915 to $9.77 in 1916. In the Mother Lode region the principal deep mine center is in and about Jackson and Sutter Creek. The six combined mines at this point produced 353,618 tons of ore, averaging $5.67 a ton in gold and silver. Other mines at other points reduced the average in Amador County to $5.02 a ton.

In the Grass Valley district of Nevada County, including mines at Nevada City, the average value of the ore produced by 18 mines in 1916 was $9.10 a ton in gold and silver. At Kennett, Shasta County, where the mines and smelter of the Mammoth Copper Co. are situ-

ated, 247,371 tons of ore were treated from all the mines, which yielded $377,034 in gold, or $1.52 a ton; $475,015 in silver, or $1.92 a ton; $5,857,312 in copper, or $23.68 a ton; $1,053,806 in zinc, or $4.26 a ton—a total of $7,763,167, or $31.38 a ton, as compared with $5,668,807, or $18.29 a ton, in 1915.

The details of mining work in the Mother Lode counties are given in the section on production by counties. A condensed statement of the record of these Mother Lode counties, including all deep mines in them, is given in the following table:

*Gold and silver produced at mills in Mother Lode counties in California in 1916.*

| County. | Ore treated (short tons). | Gold and silver recovered in bullion. | | |
|---|---|---|---|---|
| | | Gold. | Silver (fine ounces). | Average value in gold and silver per ton of ore. |
| Amador | 730,098 | $2,365,447 | 20,539 | $3.258 |
| Calaveras | 360,952 | 471,447 | 3,778 | 1.313 |
| Eldorado | 12,204 | 59,403 | 416 | 4.889 |
| Mariposa | 67,328 | 337,823 | 2,429 | 5.041 |
| Tuolumne | 223,206 | 485,529 | 22,514 | 2.242 |
| | 1,393,788 | 3,719,649 | 49,676 | 2.692 |

| County. | Concentrates produced. | | | | Value of total recovery. | |
|---|---|---|---|---|---|---|
| | Quantity (short tons). | Gold. | Silver (fine ounces). | Average value in gold and silver per ton of concentrates. | Total. | Average per ton of ore. |
| Amador | 15,445 | $1,287,720 | 7,628 | $83.699 | $3,671,701 | $5.029 |
| Calaveras | 10,080 | 361,587 | 3,600 | 36.105 | 837,889 | 2.321 |
| Eldorado | 313 | 14,532 | 245 | 46.942 | 74,370 | 6.094 |
| Mariposa | 1,187 | 61,593 | 1,628 | 52.792 | 402,085 | 5.972 |
| Tuolumne | 9,949 | 366,737 | 749 | 36.911 | 867,573 | 3,887 |
| | 36,974 | 2,092,169 | 13,850 | 56.831 | 5,853,618 | 4.199 |

A comparison of this table with the corresponding one for 1915 shows a total decrease in ore treated at gold and silver mills in the five Mother Lode counties in 1916 of 128,059 tons. Every one of these counties shows more or less decrease, except Mariposa, which increased its output of ore by about 19,000 tons.

In the Mother Lode counties in 1916 there were treated at gold and silver mills 1,393,788 tons of ore, yielding in gold and silver $5,853,618, or an average of $4.199 a ton, as compared with 1,521,847 tons in 1915, yielding $6,349,772 and averaging $4.17 a ton; 1,243,529 tons in 1914, yielding $5,075,522, an average of $4.08 a ton; 1,242,343 tons in 1913, yielding $4,728,450, an average of $3.81 a ton; 1,299,988 tons in 1912, yielding $4,803,935, or $3.69 a ton; and 1,377,084 tons in 1911, yielding $4,910,358, or $3.57 a ton. In the last six years there has been an annual improvement in the grade of ore treated, notwithstanding increase in the depths to which mining is carried in

the more prominent mines. The average value of gold and silver in the concentrates per ton was $56.83, as compared with $56.56 in 1915 and $44.18 in 1914. There were 36,974 tons of concentrated obtained from the 1,393,788 tons of ore worked in these counties in 1916.

The total quantity of ore treated at gold and silver mills from the deep mines of the State in 1916, was 2,097,137 tons, which was 189,432 tons less than in 1915. Of the total ore milled, 62 per cent came from the Mother Lode counties in 1916. Amador, the largest producer of the Mother Lode counties, produced 35 per cent of the total quantity of ore milled in the State in 1916, and 52 per cent of the ore milled in the Mother Lode counties.

*Crude ore sold or treated in California in 1916, in short tons.*

| County. | Siliceous ores. | Copper ores. | Lead ores. | Silver ores. | Silver-lead ores. | Zinc ores. | Total. |
|---|---|---|---|---|---|---|---|
| Amador | 730,174 | 25 | | | | | 730,199 |
| Butte | 1,947 | | | | | | 1,947 |
| Calaveras | 413,190 | 104,990 | | | | | 518,180 |
| Eldorado | 12,494 | | | | | | 12,494 |
| Fresno | 50 | 520 | | | | | 570 |
| Humboldt | 4 | | | | | | 4 |
| Imperial | 4,023 | | 124 | | | | 4,147 |
| Inyo | 10,947 | 720 | 1,189 | | 30,131 | 20,153 | 63,140 |
| Kern | 173,041 | 464 | | | | | 173,505 |
| Madera | 1,216 | 1,189 | | | | | 2,405 |
| Mariposa | 67,328 | 1,673 | | | | | 69,001 |
| Merced | | 112 | | | | | 112 |
| Modoc | 100 | | | | | | 100 |
| Mono | 11,517 | | | | | | 11,517 |
| Nevada | 410,328 | | | | | | 410,328 |
| Placer | 16,839 | 39,873 | | | | | 56,712 |
| Plumas | 17,045 | 163,933 | | | | | 180,978 |
| Riverside | 649 | 872 | | | | | 1,521 |
| San Bernardino | 1,770 | 33,282 | 323 | 65 | 996 | 8,926 | 45,362 |
| Shasta | 19,053 | 575,356 | | | | | 594,409 |
| Sierra | 68,758 | | | | | | 68,758 |
| Siskiyou | 2,860 | 619 | | | | | 3,479 |
| Trinity | 3,565 | 10,094 | | | | | 13,659 |
| Tuolumne | 225,065 | | | | | | 225,065 |
| Yuba | 50 | | | | | | 50 |
| | 2,192,013 | 933,722 | 1,636 | 65 | 31,127 | 29,079 | 3,187,642 |
| Increase or decrease | −175,899 | +331,907 | −11,186 | −375 | +30,983 | +9,433 | +184,863 |
| Average value per ton in gold and silver | $5.469 | $2.376 | $2.682 | $76.92 | $7.879 | $1.378 | $4.549 |

*Value of ore mined and treated in California in 1916.*

| Ore. | | Total value. | | Average value per ton. | |
|---|---|---|---|---|---|
| Class. | Quantity (short ons). | In gold and silver. | In all metals. | In gold and silver. | In all metals. |
| Siliceous | 2,192,013 | $11,989,204 | $11,989,980 | $5.469 | $5.469 |
| Copper | 933,722 | 2,218,993 | 17,038,167 | 2.376 | 18.247 |
| Lead | 1,636 | 4,389 | 53,997 | 2.682 | 33.005 |
| Silver | 65 | 5,000 | 5,000 | 76.923 | 76.923 |
| Silver-lead | 31,127 | 245,273 | 836,998 | 7.879 | 26.890 |
| Zinc | 29,079 | 40,086 | 1,229,980 | 1.378 | 42.297 |
| | 3,187,642 | 14,502,945 | 31,154,122 | 4.549 | 9.773 |

The value of all metals obtained from ore mined and treated in California in 1916 was $31,154,122, an average of $9.77 a ton. In 1915 the value was $23,636,028, an average of $7.87 a ton; in 1914 it

was $16,610,509, an average of $6.74 a ton; in 1913 the figures, respectively, were $17,954,941 and $7.19; in 1912, $17,716,357 and $6.71; in 1911, $16,167,193 and $5.49; in 1910, $18,109,008 and $6.71; and in 1909, $19,715,314 and $6.48.

*Gold and silver produced in California in 1916.*

| County. | Ore to gold and silver mills. | | | Ore to concentrating mills, quantity. | Concentrates produced. | | |
|---|---|---|---|---|---|---|---|
| | Quantity. | gold. | Silver. | | Quantity. | Gold. | Silver. |
| | *Short tons.* | | *Fine ounces.* | *Short tons.* | *Short tons.* | | *Fine ounces.* |
| Amador | 730,098 | $2,365,447 | 20,539 | ..... | 15,445 | $1,287,720 | 7,628 |
| Butte | 1,715 | 12,142 | 55 | ..... | 20 | 4,341 | 568 |
| Calaveras | 360,952 | 471,447 | 3,778 | ..... | 10,080 | 361,587 | 3,600 |
| Eldorado | 12,204 | 59,403 | 416 | ..... | 313 | 14,532 | 245 |
| Fresno | 41 | 415 | 3 | ..... | ..... | ..... | ..... |
| Humboldt | 4 | 248 | 1 | ..... | ..... | ..... | ..... |
| Imperial | 4,000 | 21,540 | 100 | ..... | 5 | 744 | 14 |
| Inyo | 5,294 | 59,948 | 1,991 | ..... | 125 | 2,811 | 2,501 |
| Kern | 172,980 | 741,756 | 12,956 | ..... | ..... | ..... | ..... |
| Madera | 1,216 | 7,666 | 328 | ..... | 21 | 1,536 | 226 |
| Mariposa | 67,328 | 337,823 | 2,429 | ..... | 1,187 | 61,593 | 1,628 |
| Modoc | 70 | 1,902 | 84 | ..... | ..... | ..... | ..... |
| Mono | 11,287 | 235,997 | 4,593 | ..... | 1 | 308 | 1 |
| Nevada | 386,692 | 3,295,379 | 39,453 | ..... | 2,678 | 291,802 | 8,169 |
| Placer | 16,526 | 114,748 | 1,982 | ..... | 198 | 12,579 | 942 |
| Plumas | 17,045 | 70,019 | 419 | 152,566 | 7,961 | 13,003 | 46,141 |
| Riverside | 649 | 5,623 | 33 | ..... | 13 | 207 | 58 |
| San Bernardino | 10 | 248 | 1 | ..... | ..... | ..... | ..... |
| Shasta | 6,188 | 69,289 | 527 | 62,227 | 8,285 | 2,911 | 1,526 |
| Sierra | 68,753 | 638,934 | 4,391 | ..... | 167 | 16,172 | 302 |
| Siskiyou | 2,274 | 24,332 | 120 | ..... | ..... | ..... | ..... |
| Trinity | 3,555 | 39,317 | 498 | ..... | ..... | ..... | ..... |
| Tuolumne | 223,206 | 485,529 | 22,514 | ..... | 9,949 | 366,737 | 749 |
| Yuba | 50 | 517 | 3 | ..... | ..... | ..... | ..... |
| | 2,092,137 | 9,059,669 | 117,214 | 214,793 | 56,448 | 2,438,583 | 74,298 |
| Average value per ton | ..... | 4.33 | $0.037 | ..... | ..... | 43.20 | $0.86 |

| County. | Crude ore to smelter. | | | Old tailings treated. | | |
|---|---|---|---|---|---|---|
| | Quantity. | Gold. | Silver. | Quantity. | Gold. | Silver. |
| | *Short tons.* | | *Fine ounces.* | *Short tons.* | | *Fine ozs.* |
| Amador | 101 | $2,770 | 233 | ..... | ..... | ..... |
| Butte | 232 | 2,501 | 11 | ..... | ..... | ..... |
| Calaveras | 105,727 | 86,363 | 116,558 | 51,501 | $102,615 | 1,806 |
| Eldorado | 290 | 2,956 | 25 | ..... | ..... | ..... |
| Fresno | 520 | 186 | 100 | 9 | 92 | 2 |
| Humboldt | ..... | ..... | ..... | ..... | ..... | ..... |
| Imperial | 147 | 1,054 | 122 | ..... | ..... | ..... |
| Inyo | 46,202 | 64,705 | 321,156 | 11,644 | 4,258 | 27,605 |
| Kern | 525 | 786 | 314 | ..... | ..... | ..... |
| Madera | 1,189 | 1,104 | 2,139 | ..... | ..... | ..... |
| Mariposa | 1,673 | 517 | 7 | ..... | ..... | ..... |
| Merced | 112 | ..... | ..... | ..... | ..... | ..... |
| Modoc | 30 | 827 | 53 | ..... | ..... | ..... |
| Mono | ..... | ..... | ..... | 239 | 779 | 887 |
| Nevada | 129 | 4,588 | 522 | 23,507 | 44,208 | 6,007 |
| Placer | 39,901 | 53,850 | 33,778 | 285 | 145 | 5 |
| Plumas | 11,367 | 1,408 | 23,869 | ..... | ..... | ..... |
| Riverside | 872 | 2,025 | 422 | ..... | ..... | ..... |
| San Bernardino | 43,622 | 275,700 | 101,161 | 1,730 | 2,935 | 880 |
| Shasta | 525,994 | 623,489 | 1,692,046 | ..... | ..... | ..... |
| Sierra | 5 | 207 | 14 | ..... | ..... | ..... |
| Siskiyou | 1,205 | 30,119 | 1,681 | ..... | ..... | ..... |
| Trinity | 10,104 | 20,403 | 9,442 | ..... | ..... | ..... |
| Tuolumne | 14 | 186 | 2 | 1,845 | 6,056 | 2,384 |
| Yuba | ..... | ..... | ..... | ..... | ..... | ..... |
| | 789,961 | 1,175,744 | 2,303,655 | 90,751 | 161,088 | 39,576 |
| Average value per ton | ..... | 1.488 | $1.91 | ..... | 1.77 | $0.288 |

In 1916 there was treated at gold and silver mills and at concentrating plants 2,306,930 tons of ore yielding altogether $11,498,252 in gold and 191,512 fine ounces of silver, valued at $126,015, a total value of $11,624,267 in gold and silver and an average value per ton of $5.04 in both metals. The average value in 1915 was $5.56; in 1914, $5.44; in 1913, $5.57; in 1912, $5.08; in 1911, $4.64; in 1910, $5.25; and in 1909, $4.88.

There was recovered in 1916 as bullion in mills $9,059,669 in gold and 117,214 fine ounces of silver, valued at $77,127, a total of $9,136,796 in gold and silver and an average of $4.37 a ton in both metals.

From 2,092,137 tons of gold milling ore and 214,793 tons of concentrating ores 56,448 tons of concentrates were obtained, containing $2,438,583 in gold and 74,298 fine ounces of silver, valued at $48,888. This was a yield in gold and silver of $2,487,471, or an average value recovered from the concentrates of $44.06 a ton.

Of smelting ores 789,961 tons were treated having an output of gold of $1,175,744, and of 2,303,655 fine ounces of silver, valued at $1,515,805. The total yield of gold and silver was $2,691,549, or an average of $3.40 a ton.

There were treated also 90,751 tons of old tailings, yielding $161,088 in gold and 39,576 ounces of silver, valued at $26,041. The total gold and silver produced from the tailings was valued at $187,129, an average of $2.06 a ton.

## PRODUCTION.

### GENERAL STATEMENT.

*Gold, silver, copper, lead, and zinc produced in California, 1907–1916.*

| Year. | Number of mines producing. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Value.* | *Fine ozs.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1907 | 1,061 | 2,054,653 | $16,727,928 | 1,138,858 | 28,528,020 | 2,625,419 | 233,550 | $23,338,104 |
| 1908 | 1,054 | 2,546,908 | 18,761,559 | 1,647,278 | 38,776,881 | 1,237,548 | ..... | 24,805,141 |
| 1909 | 1,127 | 3,041,688 | 20,237,870 | 2,098,253 | 57,288,281 | 1,502,597 | ..... | 28,841,050 |
| 1910 | 1,079 | 2,697,885 | 19,715,440 | 1,840,085 | 48,700,756 | 2,870,977 | ..... | 27,020,405 |
| 1911 | 1,181 | 2,797,261 | 19,738,908 | 1,270,445 | 36,316,136 | 1,398,111 | 2,807,035 | 25,174,677 |
| 1912 | 1,041 | 2,641,497 | 19,713,478 | 1,300,136 | 33,451,672 | 1,144,731 | 4,345,591 | 26,383,946 |
| 1913 | 796 | 2,495,958 | 20,406,958 | 1,378,399 | 34,575,007 | 3,514,342 | 1,057,485 | 26,812,487 |
| 1914 | 658 | 2,465,485 | 20,653,496 | 1,471,859 | 30,507,692 | 4,251,923 | 389,471 | 25,710,645 |
| 1915 | 608 | 3,002,779 | 22,442,296 | 1,678,756 | 40,751,625 | 4,579,245 | 13,094,032 | 32,263,844 |
| 1916 | 589 | 3,187,642 | 21,410,741 | 2,564,354 | 55,897,118 | 12,407,493 | 15,256,485 | 39,749,263 |
| Increase or decrease, 1916... | −19 | +184,863 | −1,031,555 | +885,598 | +15,145,493 | +7,828,248 | +2,162,453 | +7,485,419 |

In 1916 there were 589 properties reporting production in California, of which 297 were deep mines and 292 were placers. The producing deep mines of 1916 may be classified by chief metallic product as follows: Gold, 204; copper, 60; silver, 1; silver-lead, 18; lead, 11; and zinc, 3. Of the placer mines 87 were hydraulic—9 less than in 1915; 60 were dredge—2 more than in 1915; 67 were drift—6 more than in 1915; and 78 were surface or sluicing mines—6 more than in

1915. There were altogether 5 more placer mines producing than in 1915. Of deep mines there were 33 less gold mines, 17 more copper, 10 less silver, 15 more silver-lead, and 3 less zinc; there were therefore 14 less deep mines productive than in 1915. The dredges are enumerated by the number of boats at work, some companies owning only one and others several.

The total value of the gold, silver, copper, lead, and zinc produced in California in 1916 shows an increase of 23 per cent. There was an increase in quantity and value in all metals, except gold, which showed a decrease of 4.6 per cent. In copper the increase was 37 per cent in quantity and 93 per cent in value; in zinc it was 16.5 per cent in quantity and 26 per cent in value; in lead it was 171 per cent in quantity and 298 per cent in value; in silver, 53 per cent in quantity and 98 per cent in value. The yield of gold from deep mines decreased 7 per cent and that from placers less than 0.4 per cent.

*Mine production of gold, silver, copper, lead, and zinc in California, 1916.*

| County. | Ore treated. | Deep-mine gold. | | Placer gold. | | Total gold. | |
|---|---|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | *Short tons.* | *Fine ounces.* | | *Fine ounces* | | *Fine ounces.* | |
| Amador | 730,199 | 176,855.95 | $3,655,937 | 223.15 | $4,613 | 177,079.10 | $3,660,550 |
| Butte | 1,947 | 918.35 | 18,984 | 59,900.20 | 1,238,247 | 60,818.55 | 1,257,231 |
| Calaveras | 518,180 | 49,439.83 | 1,022,012 | 16,162.47 | 334,108 | 65,602.30 | 1,356,120 |
| Del Norte | | | | 19.59 | 405 | 19.59 | 405 |
| Eldorado | 12,494 | 3,719.60 | 76,891 | 13,783.49 | 284,930 | 17,503.09 | 361,821 |
| Fresno | 570 | 33.52 | 693 | | | 33.52 | 693 |
| Humboldt | 4 | 12.00 | 248 | 1,017.37 | 21,031 | 1,029.37 | 21,279 |
| Imperial | 4,147 | 1,128.98 | 23,338 | | | 1,128.98 | 23,338 |
| Inyo | 63,140 | 6,372.05 | 131,722 | | | 6,372.05 | 131,722 |
| Kern | 173,505 | 35,920.47 | 742,542 | 217.69 | 4,500 | 36,138.16 | 747,042 |
| Madera | 2,405 | 498.55 | 10,306 | | | 498.55 | 10,306 |
| Mariposa | 69,001 | 19,346.76 | 399,933 | 86.35 | 1,785 | 19,433.11 | 401,718 |
| Merced and Stanislaus [a] | 112 | | | 13,139.42 | 271,616 | 13,139.42 | 271,616 |
| Modoc | 100 | 132.02 | 2,729 | | | 132.02 | 2,729 |
| Mono | 11,517 | 11,468.94 | 237,084 | | | 11,468.94 | 237,084 |
| Nevada | 410,328 | 175,890.44 | 3,635,978 | 1,639.91 | 33,900 | 177,530.35 | 3,669,878 |
| Placer | 56,712 | 8,771.45 | 181,322 | 11,592.40 | 247,078 | 20,723.85 | 428,400 |
| Plumas | 180,978 | 4,084.25 | 84,429 | 2,368.25 | 48,956 | 6,452.50 | 133,385 |
| Riverside | 1,521 | 379.99 | 7,855 | | | 379.99 | 7,855 |
| Sacramento | | | | 88,712.73 | 1,833,855 | 88,712.73 | 1,833,855 |
| San Bernardino | 45,362 | 13,490.96 | 278,883 | 44.99 | 930 | 13,535.95 | 279,813 |
| Shasta | 594,409 | 33,653.95 | 695,689 | 11,667.86 | 241,196 | 45,321.81 | 936,885 |
| Sierra | 68,758 | 31,700.77 | 655,313 | 3,335.12 | 68,943 | 35,035.89 | 724,256 |
| Siskiyou | 3,479 | 2,634.07 | 54,451 | 18,714.16 | 386,856 | 21,348.23 | 441,307 |
| Trinity | 13,659 | 2,888.96 | 59,720 | 18,178.02 | 375,773 | 21,066.98 | 435,493 |
| Tuolumne | 225,065 | 41,530.32 | 858,508 | 470.64 | 9,729 | 42,000.96 | 868,237 |
| Yuba | 50 | 25.01 | 517 | 153,213.59 | 3,167,206 | 153,238.60 | 3,167,723 |
| | 3,187,642 | 620,897.19 | 12,835,084 | 414,847.40 | 8,575,657 | 1,035,744.59 | 21,410,741 |
| Total, 1915 | 3,002,779 | 669,204.22 | 13,833,679 | 416,441.85 | 8,608,617 | 1,085,646.07 | 22,442,296 |
| Increase or decrease | +184,864 | −48,307.03 | −998,595 | −1,594.45 | −32,960 | −49,901.48 | −1,031,555 |

[a] Dredge production combined to conceal output of single dredge.

*Mine production of gold, silver, copper, lead, and zinc in California, 1916*—Continued.

| County. | Deep-mine silver. | | Placer silver. | | Total silver. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | *Fine ounces.* | | *Fine ounces.* | | *Fine ounces.* | |
| Amador | 28,400 | $18,687 | 27 | $18 | 28,427 | $18,705 |
| Butte | 634 | 417 | 4,430 | 2,915 | 5,064 | 3,332 |
| Calaveras | 125,741 | 82,738 | 1,376 | 905 | 127,117 | 83,643 |
| Del Norte | | | 3 | 2 | 3 | 2 |
| Eldorado | 685 | 451 | 1,588 | 1,045 | 2,273 | 1,496 |
| Fresno | 105 | 69 | | | 105 | 69 |
| Humboldt | 2 | 1 | 82 | 54 | 84 | 55 |
| Imperial | 235 | 155 | | | 235 | 155 |
| Inyo | 353,254 | 232,441 | | | 353,254 | 232,441 |
| Kern | 13,270 | 8,732 | 20 | 13 | 13,290 | 8,745 |
| Madera | 2,693 | 1,772 | | | 2,693 | 1,772 |
| Mariposa | 4,064 | 2,674 | 9 | 6 | 4,073 | 2,680 |
| Merced and Stanislaus | | | 977 | 643 | 977 | 643 |
| Modoc | 137 | 90 | | | 137 | 90 |
| Mono | 5,480 | 3,606 | | | 5,480 | 3,606 |
| Nevada | 54,150 | 35,631 | 167 | 110 | 54,317 | 35,741 |
| Placer | 36,707 | 24,153 | 1,178 | 775 | 37,885 | 24,928 |
| Plumas | 70,430 | 46,343 | 302 | 199 | 70,732 | 46,542 |
| Riverside | 514 | 338 | | | 514 | 338 |
| Sacramento | | | 5,438 | 3,578 | 5,438 | 3,578 |
| San Bernardino | 102,042 | 67,144 | 3 | 2 | 102,045 | 67,146 |
| Shasta | 1,694,099 | 1,114,717 | 1,146 | 754 | 1,695,245 | 1,115,471 |
| Sierra | 4,707 | 3,097 | 295 | 194 | 5,002 | 3,291 |
| Siskiyou | 1,801 | 1,185 | 1,713 | 1,127 | 3,514 | 2,312 |
| Trinity | 9,941 | 6,541 | 1,596 | 1,050 | 11,537 | 7,591 |
| Tuolumne | 25,649 | 16,877 | 246 | 162 | 25,895 | 17,039 |
| Yuba | 3 | 2 | 9,015 | 5,932 | 9,018 | 5,934 |
| Total, 1915 | 2,534,743 | 1,667,861 | 29,611 | 19,484 | 2,564,354 | 1,687,345 |
| | 1,640,888 | 831,930 | 37,868 | 19,199 | 1,678,756 | 851,129 |
| Increase or decrease | +893,855 | +835,931 | −8,257 | +285 | +885,598 | +836,216 |

| County. | Copper. | | Lead. | | Zinc. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Amador | 2,850 | $701 | | | 6,686 | $896 | $3,680,852 |
| Butte | | | | | | | 1,260,563 |
| Calaveras | 6,460,293 | 1,589,232 | | | | | 3,028,995 |
| Del Norte | | | | | | | 407 |
| Eldorado | | | | | | | 363,317 |
| Fresno | 29,447 | 7,244 | | | | | 8,006 |
| Humboldt | | | | | | | 21,334 |
| Imperial | 6,045 | 1,487 | 18,304 | $1,263 | | | 26,243 |
| Inyo | 206,146 | 50,712 | 11,497,015 | 793,294 | 5,801,821 | 777,444 | 1,985,613 |
| Kern | 20,000 | 4,920 | | | | | 760,707 |
| Madera | 168,699 | 41,500 | 1,203 | 83 | | | 53,661 |
| Mariposa | 168,183 | 41,373 | | | | | 445,771 |
| Merced and Stanislaus | 18,528 | 4,558 | | | | | 276,817 |
| Modoc | | | | | | | 2,819 |
| Mono | | | | | | | 240,690 |
| Nevada | | | | | | | 3,705,619 |
| Placer | 708,398 | 174,266 | | | | | 627,594 |
| Plumas | 5,150,004 | 1,266,901 | | | | | 1,446,828 |
| Riverside | 71,020 | 17,471 | | | | | 25,664 |
| Sacramento | | | | | | | 1,837,433 |
| San Bernardino | 1,525,866 | 375,363 | 890,971 | 61,477 | 1,583,754 | 212,223 | 996,022 |
| Shasta | 39,759,472 | 9,780,830 | | | 7,864,224 | 1,053,806 | 12,886,992 |
| Sierra | | | | | | | 727,547 |
| Siskiyou | 27,000 | 6,642 | | | | | 450,261 |
| Trinity | 1,575,167 | 387,491 | | | | | 830,575 |
| Tuolumne | | | | | | | 885,276 |
| Yuba | | | | | | | 3,173,657 |
| Total, 1915 | 55,897,118 | 13,750,691 | 12,407,493 | 856,117 | 15,256,485 | 2,044,369 | 39,749,263 |
| | 40,751,625 | 7,131,534 | 4,579,245 | 215,225 | 13,094,032 | 1,623,660 | 32,263,844 |
| Increase or decrease | +15,145,493 | +6,619,157 | +7,828,248 | +640,892 | +2,162,453 | +420,709 | +7,485,419 |

## GOLD.

The total production of gold in California in 1916 was 1,035,744.59 fine ounces, valued at $21,410,741, a decrease of 49,901.48 fine ounces, valued at $1,031,555. The deep mines of the State yielded 620,897.19 fine ounces of gold, valued at $12,835,084. Of the deep-mine gold 92.5 per cent was derived from siliceous ore, 7.2 per cent from copper ore, 0.2 per cent from silver-lead ore, and the remainder from lead ores and zinc ores.

The decrease in the gold output of the State was due almost entirely to the deficit of nearly a million dollars from the deep mines, caused by labor strikes in the Mother Lode region, where the largest producers are situated. Some mines were closed from 40 to 60 days, product being thus curtailed. The decrease from the placers was only about $33,000. The gold output from surface placers increased to some extent, according to returns, but there was a lighter output from the hydraulic, drift, and dredge mines. The dredges yielded only $27,238 less than in 1915. Since gold dredging commenced in California, in 1898, the total output of gold from that source to the end of 1916 has been $86,873,458. Since 1898 the Oroville (Butte County) dredging field has yielded $29,442,704 in gold, not including $1,973,085 derived in the last seven years from dredges in adjacent districts in the same county; the Marysville (Yuba County) field has produced from 1903 to 1916, inclusive, $27,439,000 in gold; the Folsom (Sacramento County) field has yielded since 1902 from dredging gold valued at $18,856,531. A number of dredges are in operations in various localities in other counties of the State, but their output is not included in that of the more extensive fields named.

The placer yield of gold in 1916 was 414,847.40 fine ounces, valued at $8,575,657. The placer mines produced 40 per cent of the total gold yield for 1916 and the deep mines 60 per cent, as compared with 38 per cent for the placers and 62 per cent for the deep mines in 1915. The dredges produced 36 per cent of the total gold yield from all sources in 1916. Of the total placer gold, the dredges produced 90.6 per cent, the hydraulic mines 4.5 per cent, the drift mines 2.9 per cent, and the surface or sluicing mines 2 per cent. The three larger and more important dredging fields of the State are at Oroville, Butte County; Folsom, Sacramento County; and Marysville, Yuba County. Dredges are also operated in eight other counties—5 in Calaveras, 1 in Eldorado, 1 in Merced, 2 in Placer, 3 in Shasta, 3 in Siskiyou, 2 in Stanislaus, and 3 in Trinity. The Yuba County dredges, 13 in number, made the largest output of gold, the value being $3,140,150, an increase of $464,060. Sacramento County with 13 dredges at work made an output of $1,829,478, a decrease of $300,309. In Butte County (including Oroville and "outside" districts) 14 dredges produced $1,210,874 in gold, or $280,192 less than in 1915. This statement shows that $116,441 less gold was obtained in these three districts than in 1915, but the increase in other districts of the State reduced the total decrease in dredge output to $27,238 in 1916, as compared to 1915.

Of the 28 counties producing gold in 1916 in California, 7 yielded no placer gold and 4 yielded no gold from deep mines. Six counties produced more than $1,000,000 each in gold in 1916, as follows: Ne-

vada, $3,669,878; Amador, $3,660,550; Yuba, $3,167,723; Sacramento, $1,833,855; Calaveras, $1,356,120; and Butte, $1,257,231. The leading hydraulic mining county was Trinity; the greatest producer of gold from drift mines was Placer; the largest producer of gold from dredges was Yuba; and the largest producer from surface or sluicing mines was Eldorado. The largest increase, $464,013, in total yield of gold in 1916 as compared with 1915 was in Yuba, which was followed by Nevada with $203,156, Mono with $129,782, Mariposa with $16,141, Siskiyou with $14,591, Placer with $14,081, Stanislaus, Imperial, and Humboldt with smaller amounts. Most of the counties showed a decreased yield of gold for 1916, as Sacramento, $297,958; Butte, $288,745; Kern, $236,277; Amador, $233,575; Tuolumne, $189,866; Inyo, $186,183; Shasta, $183,963; San Bernardino, $137,154; Eldorado, $39,467; Calaveras, $35,014; Plumas, $34,055; and smaller amounts in Trinity, Modoc, Fresno, Riverside, Sierra, San Diego, Madera, and Del Norte.

*Mine production of gold in California in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | | | | Grand total. |
|---|---|---|---|---|---|---|---|---|---|
| | | Siliceous ores. | Copper ores. | Lead ores. | Silver ores. | Silver-lead ores. | Zinc ores. | Total. | |
| Amador | 223.15 | 176,848.94 | 7.01 | | | | | 176,855.95 | 177,079.10 |
| Butte | 59,900.20 | 918.35 | | | | | | 918.35 | 60,818.55 |
| Calaveras | 16,162.47 | 45,813.01 | 3,626.82 | | | | | 49,439.83 | 65,602.30 |
| Del Norte | 19.59 | | | | | | | | 19.59 |
| Eldorado | 13,783.49 | 3,719.60 | | | | | | 3,719.60 | 17,503.09 |
| Fresno | | 24.52 | 9.00 | | | | | 33.52 | 33.52 |
| Humboldt | 1,017.37 | 12.00 | | | | | | 12.00 | 1,029.37 |
| Imperial | | 1,115.00 | | 13.98 | | | | 1,128.98 | 1,128.98 |
| Inyo | | 4,824.97 | 25.15 | 44.99 | | 1,456.96 | 19.98 | 6,372.05 | 6,372.05 |
| Kern | 217.69 | 35,920.47 | | | | | | 35,920.47 | 36,138.16 |
| Madera | | 445.15 | 53.40 | | | | | 498.55 | 498.55 |
| Mariposa | 86.35 | 19,321.75 | 25.01 | | | | | 19,346.76 | 19,433.11 |
| Modoc | | 132.02 | | | | | | 132.02 | 132.02 |
| Mono | | 11,468.94 | | | | | | 11,468.94 | 11,468.94 |
| Nevada | 1,639.91 | 175,890.44 | | | | | | 175,890.44 | 177,530.35 |
| Placer | 11,952.40 | 6,215.46 | 2,555.99 | | | | | 8,771.45 | 20,723.85 |
| Plumas | 2,368.25 | 2,709.92 | 1,374.33 | | | | | 4,084.25 | 6,452.50 |
| Riverside | | 282.03 | 97.96 | | | | | 379.99 | 379.99 |
| Sacramento | 88,712.73 | | | | | | | | 88,712.73 |
| San Bernardino | 44.99 | 188.95 | 13,100.43 | 85.58 | | 116.00 | | 13,490.96 | 13,535.95 |
| Shasta | 11,667.86 | 10,869.95 | 22,784.00 | | | | | 33,653.95 | 45,321.81 |
| Sierra | 3,335.12 | 31,700.77 | | | | | | 31,700.77 | 35,035.89 |
| Siskiyou | 18,714.16 | 2,517.05 | 117.02 | | | | | 2,634.07 | 21,348.23 |
| Trinity | 18,178.02 | 2,020.97 | 867.99 | | | | | 2,888.96 | 21,066.98 |
| Tuolumne | 470.64 | 41,530.32 | | | | | | 41,530.32 | 42,000.96 |
| Yuba | 153,213.59 | 25.01 | | | | | | 25.01 | 153,238.60 |
| Merced and Stanislaus [a] | 13,139.42 | | | | | | | | 13,139.42 |
| Total, 1915 | 414,847.40 | 574,515.59 | 44,644.11 | 144.55 | | 1,572.96 | 19.98 | 620,897.19 | 1,035,744.59 |
| | 416,441.85 | 644,044.19 | 23,797.60 | 1,110.26 | 95.98 | 29.21 | 126.98 | 669,204.22 | 1,085,646.07 |
| Increase or decrease | −1,594.45 | −69,528.60 | +20,846.51 | −965.71 | −95.98 | +1,543.75 | −107.00 | −48,307.03 | −49,901.48 |

From the siliceous ore and old tailings the recovery of gold by methods of treatment in California in 1916 was as follows: By amalgamation, 413,033.24 fine ounces, valued at $8,538,155; by cyanidation, 56,973.95 fine ounces, valued at $1,177,756; by chlorination, 15,979.47 fine ounces, valued at $330,325; from concentrates sent to smelters for reduction, 78,033.90 ounces, valued at $1,613,104. Where gold-mining companies have no cyanide or chlorination plants, it is the custom to send the concentrates to smelting plants for reduction. The figures given above for cyanidation recovery are approximate only for the reason that the returns received from individual mines do not always segregate the recovery by sources. Some of the mining companies pass the pulp from the amalgamating mills direct through to their cyanide plants and give their total recovery without accounting for the quantity of gold saved by separate systems of treatment. Most of these companies do not keep any separate accounts, particularly the smaller operators.

*Value and source of placer gold mined in California in 1916.*

| County. | Hydraulic. | Dredging. | Drift. | Surface placers. | Total. |
|---|---|---|---|---|---|
| Amador | ..... | ..... | $2,380 | $2,233 | $4,613 |
| Butte | ..... | $1,210,874 | 12,004 | 15,369 | 1,238,247 |
| Calaveras | ..... | 298,480 | 28,363 | 7,265 | 334,108 |
| Del Norte | ..... | ..... | ..... | 405 | 405 |
| Eldorado | ..... | ..... | 20,696 | 40,441 | 61,137 |
| Eldorado and Placer [a] | ..... | 333,688 | ..... | ..... | 333,688 |
| Humboldt | $18,168 | ..... | ..... | 2,863 | 21,031 |
| Kern | ..... | ..... | 2,000 | 2,500 | 4,500 |
| Mariposa | ..... | ..... | ..... | 1,785 | 1,785 |
| Merced and Stanislaus [a] | ..... | 271,059 | ..... | 557 | 271,616 |
| Nevada | 4,200 | ..... | 29,700 | ..... | 33,900 |
| Placer [b] | ..... | ..... | 116,548 | 20,635 | 137,183 |
| Plumas | 28,340 | ..... | 10,008 | 10,608 | 48,956 |
| Sacramento | ..... | 1,829,478 | 4,377 | ..... | 1,833,855 |
| San Bernardino | ..... | ..... | ..... | 930 | 930 |
| Shasta | 1,116 | 231,767 | 3,000 | 5,313 | 241,196 |
| Sierra | 46,820 | ..... | 11,063 | 11,060 | 68,943 |
| Siskiyou | 138,177 | 229,484 | 1,200 | 17,995 | 386,856 |
| Trinity | 146,196 | 224,247 | ..... | 5,330 | 375,773 |
| Tuolumne | ..... | ..... | 7,745 | 1,984 | 9 729 |
| Yuba | 6,998 | 3,140,150 | 2,213 | 17,845 | 3,167,206 |
| | 390,015 | 7,769 227 | 251,297 | 165,118 | 8,575,657 |

[a] Yield of single dredge in each county combined to conceal separate output.
[b] See also Eldorado and Placer.

The 292 productive placer mines in California in 1916 yielded gold valued at $8,575,657, and 29,611 ounces of silver, valued at $19,484, a total value of $8,595,141. The decrease in gold was $32,960 and the increase in the value of the silver was $285. In production of gold the dredge properties showed a decrease of $27,238, the hydraulic mines a decrease of $30,755, the drift mines a decrease of $21,658, and the surface placer or sluicing mines an increase of $46,691. The decrease of gold from the dredge, hydraulic, and drift mines was $79,651, so that the increase in yield from sluicing mines failed to offset the decrease in the other classes of placers by $32,960.

## SILVER.

The deep-mine production of silver in California in 1916 was 2,534,743 fine ounces, valued at $1,667,861, an increase in quantity of 893,855 ounces and in value of $835,931. The larger portion of the

output, 2,303,655 ounces, valued at $1,515,805, was derived from crude smelting ores. Siliceous ores, milled and smelted, yielded 171,600 fine ounces, valued at $112,913. The largest output of silver came, as usual, from Shasta County, which produced from copper ores 1,679,455 ounces, valued at $1,105,081; from siliceous ore, 14,644 ounces, valued at $9,636; and from placers, 1,146 fine ounces, valued at $754—a total yield from the county in silver of 1,695,245 ounces, valued at $1,115,471. In 1915 the county produced 906,441 ounces, valued at $459,566. Inyo County followed Shasta in yield of silver, the output being 353,254 ounces, valued at $232,441, an increase as compared with 1915 of 100,997 ounces in quantity and of $104,547 in value. The total silver derived from deep mines of all classes and from placer mines in California in 1916 was 2,564,354 ounces, valued at $1,687,345. The silver obtained from refining placer gold mined in the State in 1916 was 29,611 ounces, valued at $19,484. The largest producer of placer silver was Yuba County—9,015 ounces, valued at $5,932.

With the steady advance in price of silver has come a reopening of some old silver and silver-lead mines. Silver derived from purely silver ores in 1916 amounted to 7,599 fine ounces, valued at $5,000. From 31,127 tons of silver-lead ores there was derived 323,339 ounces of silver, valued at $212,757, as well as $32,516 in gold; from 1,636 tons of lead ore was obtained 2,129 ounces of silver, valued at $1,401; and from 29,079 tons of zinc ore the silver yield was 60,293 ounces valued at $39,673.

*Mine production of silver in California in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | | | | Grand total. |
|---|---|---|---|---|---|---|---|---|---|
| | | Siliceous ores. | Copper ores. | Lead ores. | Silver ores. | Silver-lead ores. | Zinc ores. | Total. | |
| Amador | 27 | 28,189 | 211 | | | | | 28,400 | 28,427 |
| Butte | 4,430 | 634 | | | | | | 634 | 5,064 |
| Calaveras | 1,376 | 9,932 | 115,809 | | | | | 125,741 | 127,117 |
| Del Norte | 3 | | | | | | | | 3 |
| Eldorado | 1,588 | 685 | | | | | | 685 | 2,273 |
| Fresno | | 5 | 100 | | | | | 105 | 105 |
| Humboldt | 82 | 2 | | | | | | 2 | 84 |
| Imperial | | 116 | | 119 | | | | 235 | 235 |
| Inyo | | 3,067 | 5,125 | 1,549 | | 283,220 | 60,293 | 353,254 | 353,254 |
| Kern | 20 | 12,966 | 304 | | | | | 13,270 | 13,290 |
| Madera | | 555 | 2,138 | | | | | 2,693 | 2,693 |
| Mariposa | 9 | 4,056 | 8 | | | | | 4,064 | 4,073 |
| Modoc | | 137 | | | | | | 137 | 137 |
| Mono | | 5,480 | | | | | | 5,480 | 5,480 |
| Nevada | 167 | 54,150 | | | | | | 54,150 | 54,317 |
| Placer | 1,178 | 3,180 | 33,527 | | | | | 36,707 | 37,885 |
| Plumas | 302 | 386 | 70,044 | | | | | 70,430 | 70,732 |
| Riverside | | 91 | 423 | | | | | 514 | 514 |
| Sacramento | 5,438 | | | | | | | | 5,438 |
| San Bernardino | 3 | 985 | 52,878 | 461 | 7,599 | 40,119 | | 102,042 | 102,045 |
| Shasta | 1,146 | 14,644 | 1,679,455 | | | | | 1,694,099 | 1,695,245 |
| Sierra | 295 | 4,707 | | | | | | 4,707 | 5,002 |
| Siskiyou | 1,713 | 1,410 | 391 | | | | | 1,801 | 3,514 |
| Trinity | 1,596 | 571 | 9,370 | | | | | 9,941 | 11,537 |
| Tuolumne | 246 | 25,649 | | | | | | 25,649 | 25,895 |
| Yuba | 9,015 | 3 | | | | | | 3 | 9,018 |
| Merced and Stanislaus | 977 | | | | | | | | 977 |
| Total, 1915 | 29,611 | 171,600 | 1,969,783 | 2,129 | 7,599 | 323,339 | 60,293 | 2,534,743 | 2,564,354 |
| | 37,868 | 272,849 | 1,056,895 | 127,958 | 51,428 | 17,076 | 114,682 | 1,640,888 | 1,678,756 |
| Increase or decrease | −8,257 | −101,249 | +912,888 | −125,829 | −43,829 | +306,263 | −54,389 | +893,855 | +885,598 |

From the siliceous ore and old tailings treated in California in 1916 the recovery of silver by amalgamation was 94,008 fine ounces, valued at $61,857; by cyanization, 75,369 ounces, valued at $49,593; by chlorination, 634 ounces, valued at $417; and from concentrates sent to smelters, 61,077 fine ounces, valued at $40,189. From smelting ores silver was recovered amounting to 2,303,655 fine ounces and valued at $1,515,805. These figures do not include the comparatively small quantity of silver recovered with the gold in placer-mining operations.

## COPPER.

The mine production of copper in California in 1916 was 55,897,118 pounds, valued at $13,750,691, an increase of 15,145,493 pounds and of $6,619,157 in value over the production of 1915. Copper was produced in Amador, Calaveras, Fresno, Imperial, Inyo, Madera, Mariposa, Merced, Placer, Plumas, Riverside, San Bernardino, Shasta, Siskiyou, and Trinity counties. The largest production, as usual, came from Shasta County, which produced 39,759,472 pounds, valued at $9,780,830, an increase of 8,971,626 pounds in quantity and of $4,392,957 in value. Altogether there were 933,722 tons of copper ore treated in 1916, or 331,907 tons more than in 1915. The smelter of the Mammoth Copper Co. continues to be the only one in operation in Shasta County, the others remaining closed because of the smelter-fume injunctions. The Balaklala ore was sold to the Mammoth Copper Co., as was that of the Bully Hill Co. The Mammoth Co. also treated considerable ore from small sulphide mines in different parts of the county. The Mountain Copper Co., Keswick, Shasta County, ships its ores about 250 miles by rail to the company's smelter, near Martinez, on San Francisco Bay. During the year a concentration mill was erected on one of its mines, the Minnesota, with a capacity of 250 tons a day, and these concentrates are also shipped to Martinez. The ore of the Engels mine, Plumas County, is concentrated by the flotation process and concentrates are shipped to Salt Lake City, Utah. The Calaveras Copper Co., Calaveras County, in 1916 installed an oil flotation mill of 400 tons daily capacity, and concentrates are shipped to Tacoma, Wash. The Penn Mining Co., of Calaveras County, has a 200-ton smelter for reverberatory smelting of crude ore. In 1916 a converter was installed, so that now blister copper is shipped for refining to the American Metal Co. The copper ores of California in 1915 yielded, in addition to the copper, 44,644.11 fine ounces of gold, valued at $922,876, and 1,969,783 ounces of silver, valued at $1,296,117.

## LEAD.

The mine production of lead in California in 1916 was 12,407,493 pounds, valued at $856,117, as compared with 4,579,245 pounds, valued at $215,225, in 1915. From lead ore was obtained also 144.55 fine ounces of gold, valued at $2,990, and 2,129 ounces of silver, valued at $1,401. The total value of the output from the lead-mining industry of the State in 1916, in lead and contained value of gold and silver, was $860,508. This refers to ores classified as lead ores only, and does not include gold and silver obtained from those ores classified as silver-lead. Most of the lead was obtained from Inyo

County, although there was a considerable quantity from San Bernardino and Imperial counties and a small quantity from Madera County.

### ZINC.

The recoverable mine production of zinc in California in 1916 was 15,256,485 pounds, valued at $2,044,369, as compared with 13,094,032 pounds, valued at $1,623,660, in 1915, an increase for 1916 of 2,162,453 pounds in quantity and $420,709 in value. The largest quantity was from Shasta County and next in rank was Inyo County. The production of zinc in 1916 is the record one for the State, the yield being 2,162,453 pounds in excess of the quantity for the highest previous year. The zinc output in 1916 was from the counties of Shasta, Inyo, San Bernardino, and Amador in the order named.

## PRODUCTION BY COUNTIES.

### AMADOR COUNTY.

There were 17 producing mines in Amador County in 1916, 5 less than in 1915. The quantity of ore decreased 89,499 tons and the output of gold $233,575. The silver decreased 11,827 fine ounces and the copper 1,333 pounds. The total decrease in value of all metals in the county for the year was $234,414. The yield of zinc reported in 1916 was 6,686 pounds, valued at $896. Amador continued to lead all other counties in the State in quantity of ore treated with 730,199 tons, exceeding the next county in rank, Shasta, by 135,790 tons. Amador ranked second in the production of gold, being displaced by Nevada County. The gold produced in Amador County in 1916 was valued at $3,660,550, the silver at $18,705, copper at $701, and zinc at $896. There were two productive placer mines in the county in 1916 and 15 deep mines.

Of the total output of ore 25 tons of copper ore and 76 tons of siliceous ore were shipped to smelters, and 730,098 tons (99.9 per cent of the total quantity) were treated in gold and silver mills. From this milling ore $2,365,447 in gold and 20,539 ounces of silver, valued at $13,515, were saved as bullion and 15,445 tons of concentrates were obtained, which yielded $1,287,720 in gold and 7,628 ounces of silver, valued at $5,019. The value of the total yield of gold and silver from milling ore was $3,671,701, an average value of $5.03 a ton. No old tailings were treated in 1916. The ore shipped to the smelters yielded $2,770 in gold and 233 fine ounces of silver, valued at $153, in addition to the copper and zinc. The yield of the placers in the county was $4,613 in gold and 27 ounces of silver. The decrease of gold from placers was $2,646 in 1916 as compared with 1915.

At or near Amador City there are three important producing deep mines. The Bunker Hill Consolidated Mining Co. is opened by an incline shaft 2,500 feet deep and drifts on various levels. The equipment consists of a 40-stamp mill, and a ball mill for regrinding sands, added in 1916. At the property of the Keystone Mines Co. the incline shaft is 2,600 feet deep. The ore is crushed in a 60-stamp mill equipped with Frue vanners. The mine of the Original Amador Con-

solidated Mines Co. is developed by an 850-foot incline shaft and about 2,000 feet of drifts, crosscuts, and raises. At this property the ore is crushed by Blake and disk crushers, passed through one ball mill and one pebble mill, and amalgamated on plates; the concentrates are cyanided and tailings are stored in a retaining dam. In 1916 this company discarded stamps and raised the milling capacity from 125 to 150 tons daily by converting a conical pebble mill into a ball mill. The Treasure Mining Co. started milling operations in 1916 by installing one ball and two pebble mills having Diester and Wilfley tables and Frue vanners. The property is opened by an incline shaft 1,600 feet deep and a 400-foot inclined winze. At Drytown the Fremont Consolidated Mining Co. owns the Gover, North Gover, Loyal Lode, and Fremont mines, all consolidated and working as one property. This is being developed through two incline shafts, 1,550 feet and 2,800 feet deep, respectively. About 400 feet of shaft was sunk in 1916. The reduction equipment consists of a 40-stamp amalgamation and concentration mill. The property was closed down about six weeks in 1916 owing to a labor strike. A slime plant at this mine, operated by the California Slimes Consolidated Co., is equipped with a tube mill and the tailings, etc., are concentrated and cyanided. A small output was also made at Drytown by the Phelps mine. The Ione Iron & Coal Co., at Ione, did not operate, but some ore sorted from the dump was shipped in 1916.

The deep mines in and around Jackson and Sutter Creek are the most important producers on the Mother Lode in the State. The Argonaut is developed by a 4,500-foot incline shaft, now representing a vertical depth of somewhat over 4,000 feet—the deepest gold mine in the United States. At this depth very high grade ore (for a Mother Lode property) was taken out during the year. The equipment consists of a 40-stamp mill—increased to 60 stamps since the close of the year—with classification and additional slime treatment. The property was closed for 50 days during a labor strike in 1916. The Kennedy, the heaviest producer of all Mother Lode properties in the State, has reached 4,000 feet in vertical depth in its main shaft. The property is equipped with a 100-stamp amalgamation and concentration mill. The concentrates are treated in a chlorination plant at the mine. The Central Eureka Mining Co., at Sutter Creek, is developed by a 3,490-foot incline shaft and is equipped with a 40-stamp amalgamation and concentration mill. The South Eureka Mining Co., at the same place, is developed by a shaft 2,730 feet deep on the incline. The equipment consists of one 80-stamp amalgamation and concentration mill. The property was closed during September and October owing to labor strikes. At Plymouth, the Plymouth Consolidated Gold Mines (Ltd.) made quite a large production in 1916. The plant consists of 30 stamps, 2 Hardinge mills, and 30 vanners, and has a capacity of 350 tons daily. A few small placer mines were worked productively in this county in 1916 at both Plymouth and Volcano.

### BUTTE COUNTY.

In 1916 there were 29 mines reporting production in Butte County, or six less than in 1915. There were 1,947 tons of ore treated in 1916, or 1,900 tons more than in 1915. The total gold output of the

county was $1,257,231, a decrease of $288,745, as compared with 1915. The total value of gold and silver produced in the county in 1916 was $1,260,563, a decrease of $288,846. The 14 dredges in the county mined gold to the value of $1,210,874, which was $280,132 less than 17 dredges obtained in 1915. The number of dredges operating was three less than in 1915; available ground was worked out so that a few dredges were abandoned or dismantled for removal to other fields. No hydraulic mines reported production in 1916. The five drift mines produced $1,742 less gold and the six surface or sluicing placers $15,541 less gold than in 1915. The total gold output from placers of all kinds was $1,238,247, as compared with $1,541,366 in 1915, a decrease of $303,119. The output of deep mines in gold was $18,984 in 1916, an increase of $14,374. Butte County is the third in rank in output of dredge gold, being exceeded by both Yuba and Sacramento counties.

In 1916 the Oroville district proper yielded from the dredging industry $970,409 in gold, which was $200,906 less than in 1915. The combined dredges in the county, in the Honcut and Butte Creek fields, outside of Oroville district, yielded $240,465 in gold, as compared with $319,751 in 1915.

In 1916 the following dredging companies were operating in the Oroville field, each with one machine unless otherwise noted: Natomas Co. of California (3), Oroville Dredging (Ltd.) (2), Oro Water, Light & Power Co. (2), Pacific, and Oroville Union.

The companies producing at Butte Creek and Honcut, outside the Oroville district, are the Butte Creek Consolidated, Drexler, Pacific, Honcut, and Kentucky Ranch. The dredge of the Butte Creek Consolidated Co. was dismantled in July, 1916, and the real estate disposed of. In the case of the Drexler dredge the ground available was entirely worked out at the end of the first nine months of 1916.

A few small unimportant placers were productive in 1916 at Bangor, vicinity of Chico, Enterprise, Magalia, Nimshew, Oroville, and Sterling City.

The few productive deep mines in the county are the Mugford Mining Co., Chico; Surecase, at Forbestown (equipped with a 20-stamp mill); and Triumph, at Lumpkin (equipped with a 2-stamp and a roller mill).

## CALAVERAS COUNTY.

In Calaveras County, one of the Mother Lode counties, the quantity of ore mined and milled in 1916 was 518,180 tons, an increase of 99,524 tons over 1915. The total yield of gold in 1916 was $1,356,120, a decrease of $35,014; of silver 127,117 ounces, valued at $83,643, an increase of 21,992 ounces; and of copper 6,460,293 pounds, an increase of 2,670,361 pounds. The total value of all metals increased by $921,325 in 1916, as compared with 1915. The value of the output of copper in the county in 1916 was $1,589,232, as compared with $663,238 in 1915, an increase of $925,994. In 1916 productive mines to the number of 42 reported—19 deep gold mines, 4 copper mines. 5 dredges, 9 drift, and 5 surface placers. From the placers, gold recovered by dredging was $298,480; that from drift mines $28,363; and that from surface placers $7,265.

The average value per ton of 360,952 tons of milling ore treated at gold and silver mills in the county in 1916 was $2.32 in gold and silver, compared with $2.33 in 1915. The average value per ton was the lowest in the Mother Lode counties, as has been the case for several years. The quantity of ore sold or treated in Calaveras County in 1916 was 518,180 tons, which yielded gold valued at $1,022,012; 125,741 fine ounces of silver, valued at $82,738; and 6,460,293 pounds of copper, valued at $1,589,232. The placer output was valued at $334,108 in gold, and 1,376 ounces of silver, valued at $905. The output of the county in 1916, in gold, silver, and copper was valued at $3,028,995.

There were 360,952 tons of ore treated at gold and silver mills, from which was obtained $471,447 in gold in bullion, and 3,778 fine ounces of silver, valued at $2,486. The total saving in bullion was valued at $473,933, or $1.31 a ton. From the 360,952 tons of ore were obtained 10,080 tons of concentrates yielding $361,587 in gold and 3,600 ounces of silver, valued at $2,369, an average in gold and silver of $36.10 per ton. The milling ore yielded $833,034 in gold; the average recovery in gold and silver was 2.32 a ton. There were 105,727 tons of smelting ore sold or treated yielding $86,363 in gold, and 116,558 fine ounces of silver, valued at $76,695, or $1.54 a ton in gold and silver; and 6,460,293 pounds of copper, valued at $1,589,232.

The total value of the smelting ore was $1,752,290, or $16.57 a ton. In addition there were treated 51,501 tons of old tailings yielding $102,615 in gold and 1,806 ounces of silver, valued at $1,188, a total of $103,803, or an average of $2.01 per ton.

The productive deep mines at Angels are the Angels Quartz Mining Co., Maltman, and Utica Mining Co. During 1916 in the Angels, they worked over old openings. The mine is equipped with a 20-stamp mill. The Utica Mining Co., operating the Gold Cliff mine, is equipped with a 100-stamp mill and 60 Frue vanners. At Campo Seco is the Penn Mining Co., a productive copper property having incline shafts to a depth of 2,900 feet. This mine is equipped with a 200-ton smelting furnace and a converter has been installed so that the 1917 output will be blister copper. The Carson-California Mining Co. and the South Carolina mines are at Carson Hill. The Calaveras Copper Co., at Copperopolis, installed in 1916 an oil flotation plant of approximately 400 tons daily capacity. This mine is developed by a vertical shaft 740 feet deep, an incline shaft 566 feet deep, adits 3,100 feet long, and 10,000 feet of drifts. In 1916 the three-compartment shaft was sunk 520 feet on the incline, and a raise from below was cut 190 feet to connect with the shaft. The old Plymouth Rock mine, at Jenny Lind, was started up again in August, 1916, and if development results are satisfactory, a flotation plant will be installed. The Melones Mining Co., one of the larger productive Mother Lode properties, is opened by an adit 7,500 feet long, a 2,000-foot incline shaft, drifts, and crosscuts. The equipment consists of a 100-stamp amalgamation and concentration mill and a 500-ton cyanide plant. At this mill the classification of sands and slimes is effected direct on the Wilfley tables. The Copper Crescent Mining Co., at Milton, was started up in October, 1916, the ore mined being shipped to smelters. The old Napoleon mine at Milton is again producing copper ore, carrying some gold and silver. The McKnight

mine, Mokelumne Hill, was operated August, September, and October, 1916. At the same place the Mokelumne Mines Co. is equipped with a 75-ton amalgamation and concentration mill, using ball mills for reduction of ore. The mill was only operated for a short period during the year. The Mitchell, at Mokelumne Hill, was also operated in a small way. At Mountain Ranch, the old Shenandoah mine was cleaned up and retimbered and a small output was made. This mine is developed by six tunnels, aggregating about 6,000 feet in length. It is equipped with a 10-stamp mill and concentrators. The Comet and Borie Bros. mines were producers at Railroad Flat. At West Point the Deer Foot mine was operated on a small scale and considerable development work was done. The mine is equipped with a 5-stamp mill and a new cyanide plant will treat tailings stacked away since the mill was built in 1914. Other deep mine producers at West Point are the Hazel Dell, Levaggi, and Yellow Aster.

The dredges at Comanche and Jenny Lind produce most of the placer gold of Calaveras County. The Oro Water, Light & Power Co. had two dredges working on the Mokelumne River at Comanche all the year. At Jenny Lind the Butte Dredging Co. operated 294 days. The dredge of the Calaveras Dredging Co., at Jenny Lind, was closed down and dismantled at the end of March, 1916; and the dredge of the Ivy L. Borden Co., at the same place, also ceased operations at the end of February, 1916. At Mokelumne Hill the productive drift mines were the Stockton Ridge, Eclipse, and What Cheer, and some small placers were oprated at Mountain Ranch, Railroad Flat, Sheep Ranch, and Valley Spring. The Rising Star and Stewart placers produced in a small way at San Andreas.

### DEL NORTE AND HUMBOLDT COUNTIES.

There are only two small productive placer mines in Del Norte County, both at Crescent City. These are the Craigs Creek and Dr. Young. No deep mines were operated.

There is only one deep mine in Humboldt County, a gold property which made a small production in 1916. The placer mines of the county are mainly at and in the vicinity of Orleans, where the following were productive in 1916: Croton Bar, Reynolds Creek, Rosalino, Salstrom, and Ten Eyck, hydraulic placers; Jungle and Little Klondike, surface or sluicing placers. Klamath River, a surface placer, and Weitchpec Bar, hydraulic placer, were operated at Weitchpec. The output of the county in 1916 was $21,279 in gold and 84 ounces of silver, valued at $55, a total value of $21,334.

### ELDORADO COUNTY.

Eldorado, one of the five Mother Lode counties, produced in 1916 gold valued at $361,821 and silver valued at $1,496, a total of $363,317. There was a decrease of 8,937 tons of ore treated and a decrease of $39,467 in gold and 396 ounces of silver. The decrease in total value of metallic output of the county in 1916, as compared with 1915, was $39,324. The ore treated at gold and silver mills, amounting to 12,204 tons, yielded bullion valued at $59,677, or an average per ton of $4.89 in gold and silver. There were 313 tons of concentrates derived from the milling ore, which yielded $14,693, or $46.94 a ton in

gold and silver. The milling ore yielded in bullion and from concentrates a total value of gold and silver of $74,370, or $6.09 a ton. There were 290 tons of ore shipped to smelters yielding a total of $2,972 in gold and silver, or an average of $10.25 a ton. In addition 9 tons of old tailings were treated yielding $93 in gold and silver.

The placer mines of the county yielded $284,930 in gold, and 1,588 ounces of silver, valued at $1,045. There were 25 producing mines in the county, of which 17 were placers and 8 were deep mines.

From the Jones mine, at Diamond Springs, the output was mainly specimen ore and sold as such, one specimen bringing $800. The Shan Tsz mine, at Eldorado, was worked on a small scale only. The 2-stamp mill at the Marigold & Frog Pond mine, Garden Valley, was operated intermittently during the year. At the same place the Rosecranz was a small producer. The Wall Town, at Latrobe, is a "pocket" mine. The Guildford, at Placerville, is opened by an adit 2,745 feet long, and a great deal of development work was done in 1916. This property, the most productive deep mine in the county, is equipped with a 15-stamp mill and concentrators. In and around Placerville several small quartz mines were operated productively; and at Shingle the California & Ohio made some output.

The most important of the placers in the county is that of the Pacific Gold Dredge Co., at Diamond Springs, near the American River, which was in operation the full year. The Manhattan placer made a small output at Garden Valley, as did the Blue Rock drift mine at Georgetown, and Bordt at Greenwood. The Grizzly Flat drift mine at Grizzly Flat was worked productively for six months. The Jinkerson, at Indian Diggings, and a few placers at Omo Ranch produced in a small way. At Placerville F. N. Hosking sluiced off an old dump from a drift mine. Other producers at this place were the Live Oak and Rising Hope. At the Deadman Flat, at Rescue, ground sluicing only is done in the rainy season; and a few placers made a small output at Shingle. The Benefeldt and the Hook and Ladder are productive drift properties at Smith Flat.

## INYO COUNTY.

There were 32 productive deep mines in Inyo County in 1916. Of these mines 8 were gold, 3 copper, 12 silver-lead, 8 lead, and 1 zinc. The total value of the output for 1916 was $1,985,613, or $731,503 more than in 1915. The value of the gold was $131,722, or $186,183 less than in 1915. The silver amounted to 353,254 ounces, valued at $232,441, making this county rank second to Shasta in yield of silver. The increase in output of silver in 1916 was 100,997 fine ounces in quantity and $104,547 in value, as compared with 1915. The output of copper in 1916 was 206,146 pounds, valued at $50,712, an increase in quantity of 54,378 pounds and in value of $24,153. The lead output was 11,497,015 pounds, valued at $793,294, as compared with 4,347,967 pounds, valued at $204,355 in 1915, an increase in quantity of 7,149,048 pounds and in value of $588,939. The production of zinc in 1916 was 5,801,821 pounds, valued at $777,444, an increase in quantity of 1,145,394 pounds and in value of $200,047, as compared with 1915.

There were treated in 1916 in Inyo County 63,140 tons of ore, of which 10,947 tons were siliceous ore, 720 tons copper ores, 1,189 tons

lead ores, 30,131 tons silver-lead ores, and 20,153 tons zinc ores. The deep mines in 1916 yielded gold valued at $131,722 and 353,254 fine ounces of silver. Of the gold 4,824.97 fine ounces, valued at $99,741, were obtained from siliceous ore; from copper, $520; from lead ores, $930; from silver-lead ores, $30,118; and from zinc ores, $413. The production of silver from siliceous ore was 3,067 fine ounces, valued at $2,018; from copper ores, 5,125 fine ounces, valued at $3,372; from lead ores, 1,549 fine ounces, valued at $1,019; from silver-lead ores, 283,220 fine ounces, valued at $186,359; and from zinc ores, 60,293 fine ounces, valued at $39,673. The siliceous ore therefore yielded $101,759 in gold and silver; the copper ores, $3,892; the lead ores, $1,949; the silver-lead ores, $216,477; and the zinc ores, $40,086, a total of $364,163 in gold and silver.

The Red Bridge Gold Mining Co. is a new deep-mine producer at Ballarat. At Big Pine the producers were the Fish Springs Hill and Montezuma, the latter a lead mine. Watterson & Co. shipped lead ores from Bishop. At Darwin the Christmas Gift produced lead ore of shipping grade, as did the Columbia and a few other small properties. The most important property at this place is the Darwin Development Corporation, the lead ores of which carry some gold and considerable silver. The ores of this company came from the Lucky Jim and Promontory mines at Darwin and the Jumbo mine at Keeler. The reduction plant at the property consists of a 25-ton "Murex" mill, with oil and magnetic separation and table concentration. The Black Eagle, at Independence, was worked in a small way.

The most important mining property in the county is that of the Cerro Gordo Mines Co., a zinc mine, at Keeler, the ores of which carry, in addition to zinc, a great deal of lead and silver and some gold. The vertical shaft at this mine is 900 feet deep and 4,014 feet of development work in drifts, crosscuts, raises, and winzes was performed in 1916. Electric power was substituted for steam early in the year, but the steam plant stands ready in case of interruptions in the electric-power service. Many additions have been made to the mine equipment in the form of new drills, machinery, etc. The net cost of all ore mined was $11.08 a ton and the net profit $17.65 a ton. The active operations of this company began on October 1, 1915, upon the expiration of a five-year lease of the property. Also at Keeler is the Estelle Mining Co., a lead property, which is developed by an adit 7,100 feet in length and drift 938 feet long. The principal vein and ore zone for which this extensive adit was projected were intersected during the later part of 1916. The Santa Rosa Lead & Silver Mining Co. mine, at Keeler, was worked from June, 1916, both by the company and by a system of leases. Other lead mines near Keeler, which produced in 1916, are the Spear, Royal Group, and Ygnacio Mining Co. The San Lucas is a productive copper property at the same place. At Lone Pine the Antone & Pobst and the Nellie H. mines were both productive; the Madison produced some lead at Shoshone. The Skidoo Mines Co., at Skidoo, is equipped with a 15-stamp amalgamation mill and leaching plant. The property was closed at the end of May, 1916, and subsequently leased to Davis & Westman. At the same place the Harrisburg Mines Co. produced considerable gold. In the Ore Gulch mine, at

Tecopa, much of the work in 1916 was extending the tunnel to get more depth on the vein. The lead ore was shipped to a smelter. The Silver Rule and Silver groups, at the same place, both shipped lead ore during the year. The most extensive property at Tecopa is that of the Tecopa Consolidated Mining Co., which operates the Gunsight, Noonday, and Grant mines under one management. The greater value in the ore is lead, but considerable silver and gold were also obtained. Several smaller properties at this place made shipments of lead ore during the year. The Ophir, at Trona, shipped a goodly quantity of silver-lead ore, carrying also some zinc. The Carbonate Lead Mines Co., at Zabriskie, shipped lead ore carrying a good quantity of silver and some gold and copper. Other lead-ore shippers from this camp were the Fraser and Blue Monster. The Keane Wonder, the nearest post office to which is Rhyolite, Nev., produced gold and some silver.

### KERN COUNTY.

Of the 20 mines reporting production in Kern County in 1916 only two were placers. The total value of the metallic output of the county decreased from $999,146 in 1915 to $760,707 in 1916. The total production of gold in the county in 1916 was $747,042, as compared with $983,319 in 1915. The silver output in 1916 was 13,290 ounces, valued at $8,745, as compared with 26,265 ounces, valued at $13,316, in 1915. Copper to the amount of 20,000 pounds, valued at $4,920, was produced in 1916, compared with 1,571 pounds, valued at $275, in 1915. No production of lead was reported in 1916.

There were treated 173,505 tons of ore in 1916, of which 173,041 tons were siliceous ore and 464 tons copper ore. A total of 172,980 tons were sent to gold and silver mills and 525 tons to the smelters. The yield in bullion from the ore treated at gold and silver mills was $741,756 in gold and 12,956 fine ounces of silver, a total bullion value of $750,281 in gold and silver, an average value per ton of $4.34. No concentrates were derived from this ore. From the 525 tons of ore sent to the smelters there was obtained $993 in gold and silver, or an average of $1.89 a ton. In addition, the 525 tons of ore sent to the smelters yielded 20,000 pounds of copper. The total yield of the county in gold, silver, and copper from the deep mines was $756,194, an average of $4.36 a ton of ore treated. Two placers yielded gold valued at $4,500 and 20 ounces of silver valued at $13.

The ores from the Early Sunrise mine at Isabella were milled at the plant of the Mammoth Mining Co. at the same place. The Caldwell made only a nominal output. The Keyes Mining Co. has as equipment a 5-stamp amalgamation mill. The Shipsey Mining Co. operated the King Solomon group at Johannesburg continuously during the year, using a 5-stamp amalgamation mill for reducing the ore. The Stanford Mining & Reduction Co. mined and treated tungsten ores only during the year. At Loraine a small quantity of gold was obtained by the Zenda Mining Co. On the mine of the Trio Mining Co., at Soledad Peak, near Mojave, a 10-foot Lane mill concentrator and hoist was installed in 1916. The Butte Lode Leasing Co., at Randsburg, used a ball mill in 1916, but discarded it and later resumed the use of the old 10-stamp mill. The Consolidated Mines

Co. used its 5-stamp amalgamating mill only about six months of the year 1916. The Royal Bohee (Mascot) was worked by lessees, as was the Pay Day mine. The Santa Ana only milled a few hundred tons of ore. The only really large producer at Randsburg is the Yellow Aster, which operated its 100-stamp amalgamating mill, but did not use its old 30-stamp mill during the year. At Rosamond the Tropico Mill & Mining Co. made quite a large output. The mine is developed by two shafts, 500 and 300 feet on the incline, respectively, and a 750-foot adit. The reduction plant consists of a 10-stamp mill and cyanide plant. During 1916 the latter was rebuilt, a new electric hoist constructed, and the power changed from steam and gasoline to electricity. This company also owns the 10-stamp mill and property formerly known as the Fairview and the 5-stamp mill and property of the Antelope Mining Co. Both these mills are partly dismantled. The Blue Mountain, at White River, is a gold mine equipped with a 5-stamp mill. The Weringer Mines Co., at Woody, produced copper ore in 1916. The few placers in the county producing in 1916 were at Piute and Ricardo, one being a "dry-washing" mine.

### MADERA COUNTY.

This county produced a total of $53,661 in metals in 1916, as compared with $40,028 in 1915, an increase for the year of $13,633. There were 2,405 tons of ore worked, yielding $10,306 in gold; 2,693 fine ounces of silver, valued at $1,772; 168,699 pounds of copper, valued at $41,500; and 1,203 pounds of lead, valued at $83, a total of $53,661. There were 3 deep gold mines and 5 copper mines reporting production in 1916, but no placers.

The Kroromick Mining Co., at Coarsegold (formerly the Texas Flat Mines Co.) has its property developed by a 900-foot incline shaft and two 800-foot drifts on the 750-foot and 875-foot levels, respectively. The property is equipped with a 20-stamp mill and was operated a few months only in 1916. Mill runs were made on the different ore shoots encountered during development work. At O'Neals, the Mud Springs and Keating and a few small quartz mines, made nominal outputs during the year. The Buchanan mine, near Raymond, was worked by a lessee, the copper ore being shipped to the Mammoth smelter at Kennett, Shasta County. Other copper producers near Raymond were the Copper Queen, Halliday, San Jose (of the Cavan group), and Madera County, the last being the most productive.

### MARIPOSA COUNTY.

Mariposa, one of the Mother Lode counties, showed an increase in its metallic output in 1916, as compared with 1915, the gain being $34,141 in value. The total value in 1916 was $445,771; in 1915 it was $411,630. There were 16 mines operating in 1916, of which 14 were deep mines. The output of ore increased by 20,153 tons. The output of gold was $401,718 in 1916, as compared with $385,577 in 1915, an increase of $16,141. The silver output decreased 217 ounces, and the copper increased 34,738 pounds.

The deep mines produced 69,001 tons of ore, of which 1,673 tons went to the smelter. The 67,328 tons of ore that went to the gold and

silver mills yielded $337,823 in gold as bullion, and 2,429 ounces of silver, valued at $1,598, the total gold and silver value of the bullion being $339,421, or an average value per ton of $5.04. From this ore were also derived 1,187 tons of concentrates, which yielded $61,593 in gold and 1,628 ounces of silver, valued at $1,071, a total of $62,664. The concentrates, therefore, yielded an average per ton of $52.79 in both gold and silver. The 1,673 tons of ore shipped to the smelter yielded $517 in gold, 7 ounces of silver, valued at $5, and 168,183 pounds of copper, valued at $41,373, an average value per ton for gold, silver, and copper of $25.04. The siliceous ore yielded on the plates and from the concentrates a total value of $402,085 in gold and silver, an average value per ton of $5.97.

There are a few small quartz mines operating near Bagby, but their combined output was small. The Green Mountain Consolidated Copper Co., at Ben Hur, shipped copper ore to custom smelters, as it has no reduction works of its own. The White Gulch Mining Co., at Coulterville, operating the Virginia mine, made a considerable output of gold and silver in 1916. The equipment consists of a 10-stamp amalgamation and concentration mill. The Original Mining Co., at El Portal, was a considerable producer of gold. The reduction equipment is a 10-stamp amalgamation and concentration mill. There were several producers of gold at and near Hornitos, the principal one of which was the Ruth Pierce mine, which has an equipment of 10-stamps and two Frue vanners. At Jerseydale some output of gold was made by the Poor mine. The Pocahontas Copper Co., at Lewis, produced copper ore only, as did the White Rock, at the same place. Copper ore was also produced by the Colorado & Weston-Judkins Co., at Mariposa, the ore being shipped to smelters. The extensive property of the Mariposa Commercial & Mining Co., at Mount Bullion, was not operated by the company, but prospectors and lessees worked the ground in many places productively. Since the close of the year the company has disposed of its interest in the property. The Mountain King Mining Co., at Mountain King, has its property opened by an adit 980 feet in length, 6,300 feet of drifts, and 1,400 feet of crosscuts. Extensive development work was performed during 1916. The equipment consists of a 20-stamp amalgamation and concentration mill. A new electric hoist was installed in 1916. The Lookout mine, near Raymond, shipped some copper ore during the year. A few small placer mines operated productively at Jerseydale and Whitlock.

### MONO COUNTY.

The total value of the metal output in Mono County increased from $109,225 in 1915 to $240,690 in 1916, or $131,465. The increase in gold was $129,782. The output of silver increased from 3,793 ounces, valued at $1,923, in 1915 to 5,480 ounces, valued at $3,606, in 1916, or 1,687 ounces in quantity and $1,683 in value. There was no copper reported in 1916.

There were 11,287 tons of crude ore treated at the gold and silver mills, which yielded $235.997 in gold and 4,593 fine ounces of silver, valued at $3,022, a total value of $239,019, and an average value per ton of $21.18 in gold and silver. Only one ton of concentrates was

produced, which yielded $309 in gold and silver. There were 230 tons of old tailings treated, which yielded $1,362 in gold and silver, or an average of $5.92 a ton. The total value for the 11,517 tons of ore was therefore $240,690 in gold and silver, or an average value per ton of $20.90. No ore was sent to the smelter.

The old Standard mine at Bodie, the leading gold producer of the county for many years, is now in the hands of an individual owner instead of a company. Although considered virtually worked out, development work and milling having stopped, it again became productive in 1916 and the mill was operated when there was sufficient ore to be treated. The equipment of this mine consists of a 20-stamp plate amalgamation mill and a 100-ton cyanide plant. The Golden Gate mine, at Colville, made only a small output. The largest producer in the county is the Serita Mining Co., at Masonic. The Don Alvarado made a small gold output at Mono Lake.

## NEVADA COUNTY.

Nevada County was the leading producer of gold in California in 1916, superseding Amador County which held that distinction in 1915. It is also one of the three counties of the State that exceeded the three-million mark in yield of gold in 1916, its output having been $3,669,878—an increase of $203,156 over 1915. The production of gold from deep mines increased $207,493; the placer gold decreased $4,337. The average value per ton of ore treated in gold and silver in this county was $8.95.

The quantity of ore treated in the county in 1916 was 410,328 short tons. There were 28 productive mines, of which 22 were deep gold mines and 6 were placers. The hydraulic mines produced in gold $4,200 and the drift mines $29,700, a total value of $33,900 from the placers. The deep mines produced gold valued at $3,635,978 and silver valued at $35,631, a total value of $3,671,609.

There were 386,692 tons of siliceous ore treated at the gold and silver mills; 129 tons were sent to smelters; and 23,507 tons of old tailings were treated. The value of the gold in the mill bullion was $3,295,379, an average value of $8.52 a ton, and the silver output from the same source was 39,453 fine ounces, valued at $25,960, or $0.07 a ton. The total value of the gold and silver recovered in mill bullion was $3,321,339, an average value of $8.59 a ton. From the milling ore there were obtained 2,678 tons of concentrates which carried $291,802 in gold and 8,169 ounces of silver, valued at $5,375. The total value of the concentrates was $297,177 in gold and silver, or an average value per ton of $110.97. From the 386,692 tons of milling ore there was recovered from both bullion and concentrates $3,587,181 in gold and 47,622 fine ounces of silver, valued at $31,335. The total value of the gold and silver recovered from bullion and concentrates was $3,618,516, the average value per ton being $9.36 in gold and silver. The 129 tons of ore sent to the smelter yielded $4,589 in gold and 522 ounces of silver, valued at $343. There were 23,507 tons of old tailings treated, yielding $44,208 in gold, and 6,008 ounces of silver, valued at $3,953.

At Chicago Park the Little Axe mine made a small gold production. The Republic Mining Co., at Graniteville, is equipped with a

10-stamp amalgamation mill—a Huntington mill is to supplement this.

The principal quartz-mining district of Nevada County, Grass Valley, includes the important mines of both Grass Valley and Nevada City. The producing deep mines of Grass Valley in 1916 were the Ben Franklin, Brunswick Consolidated, Central Consolidated, Empire Mines, Golden Center, North Star Mines, Holbrook, Union Hill, Bellefontaine, Champion, Croesus, Granger & Gray, Montana, Oustamah, Queen Lill, and Zeibright. The Brunswick Consolidated is developed by a vertical shaft 1,230 feet deep, an incline shaft of 1,250 feet, and several miles of drifts, crosscuts, etc. A great deal of development work was accomplished in 1916. The equipment consists of two 20-stamp amalgamation and concentration mills. No cyanide plant has been installed as proposed, owing to high cost of cyanide. The Ben Franklin Mining Co. is equipped with a 10-stamp mill and concentrators. The property of the Central Consolidated Mining Co. was operated by tributers part of the time during the year, but some development work was done by the company itself. The equipment consists of a 20-stamp mill with concentrators. The Empire Mines Co., which includes several mines, is one of the most important and productive properties in the State. The Golden Center of Grass Valley Mining Co. performed 2,454 feet of shaft sinking, drifting, and raising, in 1916. The equipment consists of a 10-stamp amalgamation and concentration mill. The North Star Mines Co., one of the largest gold producers of California, is one of the few which publish details of operations in an annual report. During the year the gross production was $1,160,007; the expenses amounted to $613,102 for current operations and to $84,303 for development, leaving a profit of $462,602. The output in 1916 came chiefly from stopes above the 3,000, 3,400, and 4,400 levels. A total of 135,760 tons of rock was mined and delivered to the mills, of which 24,430 tons was sorted out as waste in the sorting plant, leaving 111,330 tons of ore crushed, which had an average yield of $10.42 per ton crushed, an average cost of $6.26 per ton crushed ($5.12 per ton mined), and a realized profit of $4.16 per ton crushed. The yield per ton crushed in 1916 was 50 cents a ton more than in 1915. Of the total production of the year 80.78 per cent was obtained in the mills by amalgamation, and 19.22 per cent was recovered by cyanidation. The plant and equipment has been concentrated near the top of the vertical shaft, and a new 60-stamp mill with heavier stamps has replaced the two old 80-stamp mills. The operation of the Champion mine, at Nevada City, owned by the Champion Mines Co., was carried on during the year, but the work resulted in a deficit of $123,329. The Providence shaft was sunk to a depth of 2,529 feet, and connection was made with the Champion vein at the 2,700-foot level. No profitable ore body of much importance has yet been opened at the bottom of the mine and no favorable conditions have been shown in the Champion property of the company since beginning. Since the North Star Mines Co. began operating in May, 1884, there have been crushed 1,469,724 tons of ore to the end of 1916, yielding, at $12.66 per ton, $18,610,534. The operating and development expenses during the same period were $11,463,789, leaving a profit of $7,146,744. Some other items brought the total

profit up to $8,648,272. Aside from cost of improvements and purchase of properties, dividends aggregating $5,087,040 have been paid to stockholders and at the end of 1916 there was a balance on hand of $910,864. The Bellefontaine mine at Nevada City is equipped with a 5-stamp amalgamation and concentration mill; and the Croesus Gold Mining Co., at the same place, has a 20-stamp mill. Lessees operated the Oustamah mine in 1916, which mine is equipped with a 10-stamp mill. The Queen Lill is a "pocket" mine and only high-grade ore is treated, as it may be found in bunches in the vien. The Zeibright mine was operated productively by the Bear Valley Mining Co.; a few small quartz mines also made some production. The Black Bear Mining Co. property was operated by tributers in 1916. The mine is equipped with a 10-stamp mill. The Gaston, a producer at Washington, is equipped with a 10-stamp amalgamation and concentration mill.

There are some small placers operating productively at French Corral and at North Bloomfield; and the Relief Hill Mining Co. is working its drift mine near Nevada City through a long tunnel and is making some production. A small output was made by the Grizzly Ridge gravel mine at North Columbia. About 7 miles north of Dutch Flat, at the old town of You Bet, the You Bet Mining Co. made a good output of gold by drifting, and some portions of the property were operated by lessees during the entire year. The Washington, on South Yuba River, at Washington, made some production by drifting bench gravel.

### PLACER COUNTY.

In 1916 Placer County produced gold and silver valued at $453,328, as compared with $438,862 in 1915, an increase of $14,466. The total yield of gold was $428,400, and that of silver was 37,885 fine ounces, valued at $24,928.

The deep mines produced from 56,712 tons of ore gold valued at $181,322; 36,707 fine ounces of silver, valued at $24,153; and 708,398 pounds of copper, valued at $174,266. The total value recovered from deep mines was $379,741. The placer mine yield was $247,078 in gold and 1,178 fine ounces of silver, valued at $775, a total of $247,853. The yield from placer mines was $16,959 more in 1916 than in 1915. The deep-mine decrease in gold was $2,862. The total metallic output for the county in 1916 was valued at $627,594, a decrease of $157,647, as compared with 1915. There were 24 producing placers in the county in 1916, 11 productive deep mines, a total of 35. Placer continues to be the leading drift mining county of the State.

Of the deep mines in the county the Banner and the Jubilee were small producers at Auburn; the Oro Fino Mining Co. at the same place made quite a large output, operating its plant continuously during the year and doing considerable development work. The mine is opened by a 400-foot incline shaft. The equipment consists of a 10-stamp amalgamation and concentration mill. During 1916 a compressor plant was installed and the classification system adopted in the mill. Small outputs were made by the Mitchell and the Reno Consolidated mining companies at Forest Hill. Landers

& Gaylord operated a copper property near Lincoln, and at the same place the Vantrent Mining Co. made the largest total output among the deep mines of the county from the Dairy Farm mine, under lease. The yield was mainly in copper, and there was also considerable gold and silver obtained. The Eureka was a small producer at Newcastle, as was the Helester Gold Mining Co. at Towle. The Pioneer Mining Co., also at Towle, is developed by adits aggregating 4,600 feet in length and some 14,000 feet of drifts, of which 700 feet were run during 1916. The equipment consists of a 20-stamp amalgamation and concentration mill and a cyanide plant. The mill was closed early in the year and only development work was carried on in the mine the rest of the year. Copper ore was produced by the Quail Mining Co., at Vantrent, with some gold and silver.

At and near Auburn the Lincoln dredge was operated continuously during 1916, and there was some gold production from surface placers also in this vicinity. At Blue Canyon the Haub drift mine was productively worked for about 10 months and the Lost Camp was worked by ground sluicing for a short period. At Butcher Ranch the dredge of the El Dorado & Placer Counties Co. produced considerable gold, and there was some output from the Christmas Hill mine at the same place. At Dutch Flat the Rough & Ready, the Union, and several small placers were productive. The Excelsior Gold Mining Co. has a very productive drift mine at Forest Hill, and there are some placers operated by Chinese in the same neighborhood. The Dayton, Gleason Consolidated, Penn Valley, and Sparahawk were productive drift mines at Iowa Hill, and several smaller properties there were also in operation. The Dixie Queen, Pacific Slab Consolidated, and Red Star were productive drift mines at Last Chance, the last named being the most important. The Pendleton and the Sequel were productive drift mines at Loomis, and at Michigan Bluff surface placers were operated productively by Chinese. The Monumental was a productive drift mine in the Reed channel, 10 miles from Westville.

### PLUMAS COUNTY.

The total metal yield from Plumas County in 1916 was $713,725 more in value than in 1915. This was owing to the great increase in production of copper, as the gold output decreased $34,055. The quantity of ore treated more than doubled.

The production of gold from deep mines was $84,429; the silver amounted to 70,430 fine ounces, valued at $46,343; and the copper to 5,150,004 pounds, valued at $1,266,901. There were 169,611 tons of ore sent to mills, of which 17,045 tons was siliceous ore and 152,566 tons copper ore. The copper ores of the county yielded a concentrate high in copper and low in gold and silver. The ore sent to gold and silver mills produced $70,019 in gold in the bullion and 419 ounces of silver, valued at $276, a total of $70,295 in gold and silver. From the ore sent to concentrating mills there were derived 7,961 tons of concentrates, yielding $13,003 in gold and 46,141 fine ounces of silver, valued at $30,361, or an average of $5.44 a ton in gold and silver. The 11,367 tons sent to the smelters yielded $1,408 in gold and 23,869 fine ounces of silver, valued at $15,706, or a total

of $17,114. The copper produced amounted to 5,150,004 pounds, valued at $1,266,901. The copper was derived from the concentrates and crude ore shipped to the smelters. There were 18 producing placers and 17 producing deep mines. Of the placers 5 were hydraulic mines, 5 were drift mines, and 8 were surface placers. The hydraulic mines produced $28,445 in gold and silver, the drift mines $10,043, and the surface placers $10,667, a total of $49,155. The drift mines increased by two and the surface placers by four in 1916, as compared with 1915. There was a decrease of $10,538 in the production of gold from all classes of placer mines in 1916.

Of the deep mines the Round Lake Mining Co., at Blairsden, after making a small output closed down the mill and ceased operations and development in May, 1916. The Last Chance Mining Co. and Murdock Mines Co. were both copper producers at Chilcoot. At Crescent Mills, a ball mill with gasoline power was put on the Jackson group of mines, and some output was derived from the property of the Golden Key Mining Co. The Plumas Amalgamated Mining Co., 6 miles from Crescent Mills, on Monitor Gulch, is equipped with a crusher and a 10-stamp mill. The Five Bears Mining Co., at Genessee, retimbered its tunnel in 1916. It is equipped with a 20-ton concentrating mill and is to put in a flotation plant. The Gruss Mining Co. is a small producer at the same place. The property of the Jamison Mining Co., at Johnsville, is opened by a 165-foot vertical shaft and a 1,800-foot drain tunnel and some thousands of feet of drifts. It is equipped with a 20-stamp amalgamation mill, but concentration was discontinued some years ago, there being no value in the concentrates. This property was closed during four of the winter months, owing to shortage of water for power. The Chicken Flat mine, at Meadow Valley, made only a nominal output. The Walker Mining Co., at Portola, is an extensive producer of copper, gold, and silver. Active development began only in August, 1916, but the vertical shaft is approximately 300 feet in depth and there is an adit 1,000 feet in length. A 75-ton flotation plant was completed and put in operation in September and the product is shipped to the International Smelter, at Tooele, Utah. The Crown Point group, near Quincy, made only a small output, but is equipped with a 10-stamp mill. Most of the work done during the year was that of development. The Oro Fino at the same place made only a nominal output. It is equipped with a 5-stamp amalgamation and concentration mill. The Engels Copper Mining Co., Taylorsville, is the most productive and extensive enterprise in the county and yields a large quantity of copper as well as considerable gold and silver. The property is opened principally by tunnels of a total length of 10,000 feet; the total development of crosscuts, raises, and a 100-foot shaft, is 5,000 feet more. During the year a 2,500-foot tunnel was being driven 250 feet below the present lowest level of the Engels group; and the Superior mine was being opened by tunnels and crosscuts. The equipment at this mine consists of a 500-ton oil flotation plant at Lights Canyon, 13 miles from Taylorsville, and this is being materially enlarged. During the year building of the first unit of a new mill with a capacity of 750 tons of ore daily was begun. The ultimate capacity of the four units will be 3,000 tons daily. Other copper producers at Taylorsville were the Sierra Range Copper Co. and Ruby. At Vinton, the Mohawk group produced some copper.

A few small placer mines were productive at Belden and Greenville, and the Great Divide made some output from bench gravel at Crescent Mills. The Continental, Standard Mining Co., and a few other small placers were productive at Johnsville. The Consolidated Alturas Mining Co., at Laporte, sluiced old tailings on Slate Creek successfully, and in this vicinity a number of small placers made a material output. At Meadow Valley the Gold Mountain Co. hydraulicked bench gravel. Surface placers producing at this point were the New York and the Old Rutherford. Near Quincy the Willow Creek Mining Co. and a number of small placers were productive. Those productive at Seneca were the Scott and the Seneca Development Co. The Spring Garden Mining Co., at Spring Garden, obtained some gold in ground sluicing by the "shooter" process. The Elizabeth made a small output on Rich Gulch near Twain.

### RIVERSIDE AND SAN DIEGO COUNTIES.

The output of ore in Riverside County in 1916 was 1,521 tons, which yielded $7,855 in gold, 514 fine ounces of silver, valued at $338, and 71,020 pounds of copper, valued at $17,471, or a total value of $25,664, which is $4,285 more than the total value in 1915. The Snowstorm mine, near Banning, has no plant and ships its ore to the Desert Queen mill, where steam was reintroduced for power, owing to high price of fuel for the gas engines. The old El Dorado mill, where Snowstorm ore was formerly crushed, was taken out in 1916. Small copper producers at Blythe were the Continental and Ironwood mines. The New El Dorado mine, at Indio, is opened by a 400-foot shaft and about 3,000 feet of lateral work. It is equipped with a 5-stamp amalgamation and concentration plant, and both mine and mill were closed in October during the installation of a cyanide plant. At Vidal the Baker Copper Co. and the Bendigo Mines Development Co. were both copper producers. The property of the Calzona Mines Co., at the same place, was worked by a lessee until November, 1916, when the company again commenced operating. The property is opened by about 4,000 lineal feet of drifts, raises, and incline shafts. The company has no reduction plant and the ore is shipped to the Consolidated Arizona smelter at Humboldt, Ariz., and the American Smelting & Refining Co. at Sasco, Ariz.

No mines reported production from San Diego County in 1916.

### SACRAMENTO COUNTY.

Sacramento is fourth in rank of the counties of California producing gold in 1916. The total output of gold in 1916 was $1,833,855, which is $297,958 less than in 1915. The output of silver decreased by 777 ounces. The total yield of gold and silver was $1,837,433, which is $297,531 less than in 1915. Practically the entire output of gold of the county was produced by dredging operations, no deep mines and only 2 small drift mines being operated. There were 13 dredges in operation in 1916, of which 11 were owned by the Natomas Co. of California, and the others by the Wilkes-Barre Dredging Co. and the Indiana Gold Dredging Co. During the year the Wilkes-Barre dredge was acquired by the Natomas Co. The output of gold by the dredges in the county in 1916 was $1,829,478, or $300,303 less than in 1915.

## SAN BERNARDINO COUNTY.

There was a decrease in the quantity of ore treated and in the gold and silver recovered in 1916 in this county, but an increase in the production of copper, lead, and zinc. The total increase in 1916 in value of all metals was $483,338. The gold decreased $137,154. Twenty-eight producing mines were reported in 1916, a decrease of 6, as compared with 1915. Silver decreased 24,513 fine ounces; copper inincreased 1,390,836 pounds; lead, 827,544 pounds; and zinc, 1,543,907 pounds. The output of gold was valued at $279,813.

The silver output in 1916 was 102,045 fine ounces, valued at $67,146; copper, 1,525,866 pounds, valued at $375,363; lead, 890,971 pounds, valued at $61,477; and zinc, 1,583,754 pounds, valued at $212,223. Four gold mines, 11 copper mines, 1 silver mine, 6 silver-lead mines, 3 lead mines, 2 zinc mines, and 1 placer mine reported production in 1916. There were 1,770 tons of siliceous ore sold or treated in 1916, 33,282 tons of copper ore, 323 tons of lead ore, 65 tons of silver ore, 996 tons of silver-lead ore, and 8,926 tons of zinc ore, a total of 45,362 tons. Of this total quantity 10 tons were treated at gold and silver mills and yielded $248 in gold and 1 fine ounce of silver. No concentrates were produced from this ore. There were 43,622 tons of crude ore sent to smelters that yielded $275,700 in gold, and 101,161 fine ounces of silver, valued at $66,564. In addition 1,730 tons of old tailings were treated, which yielded $2,935 in gold and 880 fine ounces of silver, valued at $579. The copper ores produced 13,100.43 fine ounces of gold and 52,878 fine ounces of silver; the lead ores produced 85.58 fine ounces of gold and 461 fine ounces of silver; the silver ores yielded no gold and 7,599 fine ounces of silver; the silver-lead ores 116 fine ounces of gold and 40,119 fine ounces of silver.

A small output of gold, silver, and copper came from the Supply mine at Amboy, owned by the United Greenwater Copper Co. At Barstow the producers were the Bagdad-Chase Mining Co. and the Goldstone Mining Co. At Cima the Copper World and Express and Dominion were copper producers, but the largest output at that point came from the Piute mine, which yielded copper, lead, and zinc ore, all of which was shipped to smelters. The high prices of the metals admitted of working ores of lower grade than had previously been possible. The Gibson Girl mine is the new name of the old Ord Mountain at Daggett. The King and Red Jacket, owners of the old Waterloo Co. at the same place, produced ore carrying silver only. The Uncompahgre mine, at Desert, produced considerable zinc, but no silver or gold. The Lucy Gray, at the same place, was a small producer of gold and silver. At Goffs the producing properties were the Bonanza King, Pilot, and Louisiana-California Mining Co. The output of the Bullion mine, at Ivanpah, was copper and lead ore carrying some gold. The Big Four Mining Co., at Needles, yielded copper, lead, and silver ore. The Emperor mine, at Nipton, is a copper property which produced, in addition to copper, some zinc and silver. In the last quarter of the year this company encountered a cross fissure carrying high values of silver and lead, but having the peculiar feature of an entire absence of zinc. The Crescent, also at Nipton, is a small producer of lead and silver. The Horn Copper Co., in the Turtle Mountains, has for its nearest post

office Parker, Ariz., and is a copper producer. The Pacific Mines Corporation, the heaviest producer in the county, made a large output of copper, gold, and silver. The ores of this company were shipped to the United Verde Copper Co in Arizona. A flotation mill was being designed for the property at the close of the year. The Mineral Monarch mine is a small copper producer at Stagg. At Trona the Minetta mine produced lead, copper, silver, and gold, and at the same place the Crystal Dome Mining Co. yielded lead ore carrying a little silver. The following copper mines were productive at or near Vidal: Hawkeye group, Hawley, Littlefield, and Vidal. The Ibex Spring Mining Co., Zabriskie, shipped a large quantity of ore carrying lead and zinc, the principal values being in zinc. The only placer operated in the county is that of the Coolgardie Mining Co., 14 miles from Barstow. The deposit is worked by hand dry washing, and the gold recovered has a fineness of 915.

## SHASTA COUNTY.

The metallic output of Shasta County in 1916 reached a total value of $12,866,992; the highest record yet made by the county. This is more than 43 per cent in excess of the previous high mark in 1909. The increase for 1916, as compared with 1915, was $4,857,383. The number of producing mines in the county in 1916 was 30, which is one less than in 1915. The total number of tons of ore sold or treated was 594,409, an increase of 50,137 tons. The production of gold was valued at $936,885, a decrease of $183,963. The yield of silver was 1,695,245 ounces, valued at $1,115,471, an increase in quantity of 788,804 ounces, and in value of $655,905. The output of copper of the county in 1916 was 39,759,472 pounds, valued at $9,780,830, an increase of 8,971,626 pounds in quantity and of $4,392,957 in value, as compared with 1915. The recoverable zinc was 7,864,224 pounds, valued at $1,053,806, a decrease of 533,534 pounds in quantity but an increase of $12,484 in value, as compared with 1915. Almost all of this zinc ore is sorted material shipped to the United States Smelting Co.'s plants in Kansas. Shasta continues to be the leading county of the State in total value of metallic output. It also leads all other counties in quantity and value of copper, silver, and zinc. The Mammoth smelter still remains the only one in operation in the county.

The total number of deep mines from which production was reported in Shasta County was 21, as against 24 in 1915. Of these, 13 were gold mines and 8 were copper. The output of 594,409 tons of ore was made up of 19,053 tons of siliceous ore and 575,356 tons of copper ore. The placer mines of the county in 1916 yielded 11.667.86 fine ounces of gold, valued at $241,196. This production came from 1 hydraulic mine, 3 dredges, 1 drift, and 4 surface placers.

The gold from the deep mines amounted to 33,653.95 ounces, valued at $695,689, and the silver to 1,694,099 fine ounces, valued at $1,114,717. The gold derived from siliceous ore amounted to 10,869.95 fine ounces, valued at $224,702, and that from copper ore to 22,784 ounces, valued at $470.987. The production of silver from siliceous ore was 14,644 fine ounces, valued at $9,636, and from copper ore, 1,679,455 fine ounces, valued at $1,105,081. The siliceous ore, therefore, yielded $234.338 in gold and silver, and the copper ore $1,576,068 in gold and silver.

The gold and silver mills in Shasta County in 1916 treated 6,188 tons of ore, which yielded in gold bullion $69,289, and 527 fine ounces of silver, valued at $347. The total recovery of mill bullion was valued at $69,636, or an average value per ton in gold and silver of $11.25. This ore produced 20 tons of concentrates, with a gold value of $2,167 and a silver content of 21 fine ounces, valued at $14, a total value of concentrates of $2,181. In addition to this, 62,227 tons of ore was shipped to concentrating mills, from which 8,265 tons of concentrates were derived. The average value per ton of all concentrates was $0.35 in gold and $0.12 in silver in addition to copper content.

The crude ore sent to smelters, amounting to 525,994 tons, produced (in addition to the copper) $623,489 in gold, an average of $1.18 a ton, and 1,692,046 fine ounces of silver, valued at $1,113,366, or $2.11 a ton. The total value of gold and silver recovered from the ore sent to smelters was $1,736,855, or an average value of $3.29 a ton.

The Potosi and Old Veteran mines, at Buckeye, were worked continuously during 1916 and produced gold and little or no silver. The Ruby-Pearl is a gold mine at Castella, which has a small amalgamating and concentrating mill. The Balaklala Consolidated Copper Co., one of the three heavy producers of the county, shipped all its ores to the Mammoth Copper Co. for reduction at the smelter. The main values were in the copper, but the silver and gold contents of the ore were high. At French Gulch the Accident Gold Mining Co., Niagara Mining Co., and El Dorado and Eureka group were small gold producers. The last is equipped with a 2-stamp mill and, as the ore is of low grade, the milling facilities are not adequate. The Hazel Gold Mining Co., near French Gulch, worked the Gladstone mine productively until March and then discontinued operations. This property is equipped with a 30-stamp amalgamation and concentration mill. The Summit mine, near French Gulch, is opened by a tunnel 1,400 feet long and 700 feet of drifts. The 10-stamp mill used is on an adjoining property. The Washington Mining Co. and Western Exploitation Co. are gold producers near this same place, as are a number of smaller quartz mines.

The Mammoth Copper Co., at Kennett, is the most important and productive mining and metallurgical enterprise in California. The total output in 1916 was very much larger than that of any other mining property in the State, and it exceeded all others also in the yield of copper, zinc, and silver. The company operated the Mammoth mine, at Mammoth, and the Stowell mine, at Coram, in 1916. During the year three 400-ton furnaces were in operation, two converters, and also a picking and sorting plant for zinc ores. The treatment process is straight pyritic smelting and the blister copper is shipped to the refinery at Chrome, N. J. The zinc was sorted at the smelter on a picking belt and shipped to Altoona, Iola, or La Harpe, Kans. During the year the company constructed an electrolytic zinc plant to care for fume collected in the bag house. From different parts of the county, within shipping distance of the Kennett smelter, a number of small quartz mines sent in quantities of ore carrying gold, silver, and copper. The Uncle Sam mine, at Kennett, made a small output of gold. The Mountain Copper Co. (Ltd.), with mines at Keswick, is another of the very large producing mining companies of the State, the values being mainly in copper. There

are three mines contiguous to one another—the Iron Mountain, the No. 8, and the Hornet. There is a concentration mill at the Minnesota, about 5 miles from Keswick mine. Crude ores and concentrates from that mill are transported 250 miles to the company's smelting plant at Martinez, on San Francisco Bay. This plant was in operation the whole of 1916. The sulphide ore is roasted to manufacture sulphuric acid and then the calcines, with suitable mixture of other ores, are smelted in reverberatories. The copper matte, carrying the gold and silver, is converted to blister, which is shipped to Baltimore, Md., for refining. The Victor Power & Mining Co., at Knob (or Harrison Gulch), treated old dumps of the Midas mine for most part of the year and opened up old workings for future development work. The power house of this company was destroyed by fire and new equipment was not obtained until late in 1916. Oil-burning engines have been put in. Two Lane mills are in use for crushing the ore. The cyanide plant was not in use after May, 1916. Near Redding the Greenhorn Mountain mine made a considerable output of copper ore, and in same vicinity the Gold Leaf Consolidated Co. shipped gold ore to the smelter at Kennett. The Evening Star Mining Co., at Whitehouse, made quite a large production of gold, the ore being shipped to the smelter for treatment. Both copper and silver were obtained from the mine of the Reid Mining Co. at Ydalpom, the ore being treated at the smelter.

As to gravel mines, the Rice and the Slattery & Welch are small placer producers at French Gulch, the latter being a hydraulic mine. The Shasta Dredge Co. operated a 5-cubic-foot dredge on Cottonwood Creek below Gas Point. The gravel deposit is on the bed and on the banks of the creek adjoining bottom lands. There are several small placers producing near Gas Point. The Lost Channel is a productive drift mine on Dry Creek near Igo. The Clear Creek dredge operated productively for about eight months on Clear Creek. The dredge of the Shasta Mining & Dredge Co. produced considerable gold on Cottonwood Creek. A few placers near Taylor made a small output of gold.

### SIERRA COUNTY.

The total production of metals in Sierra County in 1916 was valued at $727,547, as compared with $729,518 in 1915, a decrease of $1,971. The deep-mine gold decreased $6,621, but the placer gold increased $4,515. There were 68,753 tons of siliceous ore treated in gold and silver mills in 1916, yielding $638,934 in gold and 4,391 fine ounces of silver, valued at $2,889, a total of $641,823 in gold and silver. In addition these ores produced 167 tons of concentrates, which yielded a gold value of $16,172 and 302 fine ounces of silver, valued at $199. The average value per ton of ore in gold and silver was $9.57. In addition 5 tons of crude ore shipped to smelter yielded $207 in gold and 14 fine ounces of silver, valued at $9, a total of $216. The output of the placers in the county in 1916 was 3,335.12 fine ounces of gold, valued at $68,943, and 295 ounces of silver, valued at $194, a total of $69,137. Of this placer gold $46,820 came from hydraulic mines, $11,063 from drift mines, and $11,060 from surface placers. There were 35 productive mines in the county in 1916, of which 16 were deep-gold mines. Of the 19 placers 3 were hydraulic mines, 10 were drift mines, and 6 were surface placers.

The principal deep-mining district of Sierra County at present is Alleghany, where there are quite a number of producers. Among them the Croesus Gold Mining Co. is equipped with a 20-stamp mill. The El Dorado and the Irelan (Durston Gold Mining Co.) are small producers. The Oriental Mining Co. is equipped with a 10-stamp mill, which was only worked for a month in 1916, although work in the mine was continuous. The Original 16 to 1 mine is developed by a 795-foot shaft and 3,500 feet of drifts. Considerable development work was performed during 1916. A ball mill is in use for crushing the ore. The Tightner Mines Co. owns the most productive mine at Alleghany, which is developed by a tunnel 2,500 feet in length and a 300-foot shaft from the tunnel. The equipment consists of a 20-stamp amalgamation and concentration mill. The Twenty-one mine, at this place, made a goodly output of gold. At Downieville the producing deep mines were the Mexican and the Cliff Leasing Co. The South Fork Gold Mining Co., at Forest, made a small output only. The mine of the Four Hills Mining Co., at Johnsville, was worked under lease in 1916. The equipment consists of a 20-stamp mill. The Sierra-Alaska Mining Co., at Pike, has its property developed by a vertical three-compartment shaft 700 feet deep and about 10,000 feet of drifts. The mine and plant were only operated the first three months of 1916 owing to trouble caused by great influx of water in mine. The equipment consists of a 40-stamp amalgamation and concentration mill. The Buttes Saddle mine, at Sierra City, made only a nominal output. The Cleveland Mining Co., at the same place, is equipped with a 10-stamp amalgamation mill. The small output of the Sierra Buttes mine in 1916 was obtained from the old dumps by lessees. The equipment at the mine consists of a 60-stamp amalgamation and concentration mill and 100-ton cyanide plant, all idle during the year. The Swastika mine was worked for a short time under lease in 1916. The property is equipped with a 10-stamp mill.

There are a few unimportant drift placers producing in the vicinity of Alleghany. The Brandy City Mining Co., at Brandy City, is hydraulicking ground between the North Yuba River canyon and Cherokee Creek; and the Depot Hill hydraulic mine is producing at Depot Hill. Small drift mines near Downieville are the Grizzly Ridge, Lassiat, Monte Cristo, and Wide Awake claims. The Wisconsin-North Fork mine operated a few months only, drifting on Little Rock Creek, near Forest. Among other producing placers, mainly drift mines, are the Kirkpatrick, at Goodyears Bar; Motor Mining Co., at Port Wine; Chinese claims, at Pike; Ladies Canyon and Pig Canyon, at Sierra City; and Bruckerman, at Table Rock. At the last place the Table Rock Mining Co. and the Howland Flat Mines Co. are both productive drift claims.

### SISKIYOU COUNTY.

In 1916 Siskiyou County produced 21,348.23 fine ounces of gold, valued at $441,307; 3,514 ounces of silver, valued at $2,312; and 27,000 pounds of copper, valued at $6,642, a total of $450,261. This was an increase of $6,307, as compared with 1915. There were 11 deep mines producing, as compared with 12 in 1915. They produced 3,479 tons of ore, yielding gold valued at $54,451, and 1,801 ounces of silver,

valued at $1,185, a total of $55,636, as compared with $38,413 in 1915. The 49 producing placer mines yielded gold, valued at $386,856, and 1,713 ounces of silver, valued at $1,127, a total of $387,983, as compared with $390,384 in 1915. Thus the placers yielded $332,347 more in gold and silver than the deep mines. The number of producing mines (60) in Siskiyou County was larger than in any other county in the State; there were 6 more than in 1915. Of the placers 39 hydraulic mines produced $138,177 in gold; the 3 dredges, $229,484; the 2 drift mines and the 5 surface placers, $19,195. The hydraulic mines produced $33,200 less in gold in 1916 than in 1915.

The Royal Mining Co. and the Two-and-a-Half are producing deep mines at Callahan. The Homestake is a producer at Etna Mills, as is the Kennett Exploration Co., at Fort Jones; the China Gulch, at Hornbrook; and the Ida May and Elizabeth Sanger, at Rollin. The Oregonian group is equipped with a small 3-stamp mill at Sawyers Bar, and there are some other small quartz mines in that neighborhood. The Gipsy, Le May, and Osgood are small producers near Yreka.

The Bains and the Wandell are small placers near Black Bear. At Callahan are the Kangaroo and Sugar Hill, and a few other smaller drift and hydraulic properties; the Banner Mining Co. is operating at Cecilville. The Michigan Salmon Mining Co. is using an elevator for its gravel on the South Fork of Salmon River. The Siskiyou Dredging Co. has a dredge operating successfully in Adams Creek near Fort Jones; and the Wright Bros. have a hydraulic elevator on their claim in Oro Fino district near Fort Jones. The Sulphur Springs is a small hydraulic mine near Gottville. There are some smaller placers near Greenview; and at Hamburg are the hydraulic mines the Dick Morris, Happy Home, Hoosier Hill, Kunz Flat, and a few smaller ones. At Happy Camp the productive placers, mostly hydraulic mines, are the Davis Consolidated Mining Co., Morning Star, Camp Bar, Beck, Pine Squirrel Hill, Pocket Hill, Shady Side, Squirrel Creek, and Siskiyou Mines Co. The Jim Sterling mine was worked in a small way at Hilts, as were several placers at Hornbrook. Operating in a small way also at Oak Bar were the Gearhart, Pine Grove, Siskiyou Klondike, and Payne, mainly hydraulic mines. The Frazier is an unimportant hydraulic producer at Rollin. The following hydraulic mines were operated productively and more or less extensively at Sawyers Bar: Forks of Salmon River Mining Co., Gold Hill, Paddy Cronin, Multum in Parvo, Thomain, and William Burns. At Scott Bar and Quartz Hill and Rocky Point hydraulic mines produced, as did the Jack Lowden, at Seiad, and the Blue Nose, at Somes Bar. The Crary placer, Jensen hydraulic, and Klamath Dredging Co. were all productive at and near Walker. El Oro Dredge Co. operated its dredge at Yreka successfully 307 days in 1916.

### TRINITY COUNTY.

In 1916 Trinity County produced 21,066.98 fine ounces of gold, valued at $435,493, and 11,537 ounces of silver, valued at $7,591. The total value of all metals, including copper, was $830,575. This is an increase of $332,621 over 1915. The decrease in gold was $6,353.

There were 48 mines which reported production in 1916. Of these 6 were deep gold mines and 2 were copper mines; and of the placers 29 were hydraulic, 3 were dredges, and 8 were surface placers. The deep mines produced from 13,659 tons of ore 2,888.96 fine ounces of gold, valued at $59,720 and 9,941 fine ounces of silver, valued at $6,541, a total of $66,261 in gold and silver, as compared with $116,646 in 1915, a decrease of $50,385. The ore treated was less by 1,973 tons than in 1915. The 40 placers yielded 18,178.02 fine ounces of gold, valued at $375,773, and 1,596 ounces of silver, valued at $1,050, a total of $376,823 and an increase of $48,153.

The ore from the Packer group of mines at Coffee was crushed in an arrastre in 1916. The Brown Bear Mines, at Deadwood, are equipped with a 10-stamp amalgamation and concentration mill and have been extensively developed. The Globe Consolidated Lease operated the mine for the first four months of 1916, but no ore was developed in paying quantities by means of winzes and drifts below the adit level, so the mine was abandoned by the Globe Consolidated Lease (Inc.) after April 30, 1916. This mine is equipped, in addition to the stamp mill and tube mills, with a 100-ton cyanide plant. The Gold Hill group and the Last Chance properties, at Lewiston, were productively worked during the year, as were the Five Pines and Surprise, at Trinity Center, and the Garden Gulch Mine, at Weaverville.

At Big Bar are the Little French Bar and several other small placer mines, and at Burnt Ranch the McAtee and South Fork Gold & Platinum Co. are producers by the hydraulic system. The Little Klondike is the only producer reporting from Blocksburg. The Morrison Gulch and several other hydraulic and surface mines were productively worked at Carrville. At Coffee Creek, the Alamo, East Fork, Schlomberg, and Underground Treasure were productive placer mines. Those at Denny were the Tenner, Two Jacks, and Eagle, and a few smaller mines. A large output was made by the Trinity Consolidated Hydraulic Mines Co., at Douglas City, and there were some smaller productive placers at that point also. The productive hydraulic mines at Hayfork were the Bridge Gulch, Carrier Gulch, Drinkwater, Murphy & Layman, and Parlin, several of which are operated by Chinese. The productive hydraulic mines at Junction City were the Burger & Himeburger, Chapman & Fisher, Last Chance, and Red Hill. There were also some smaller claims which were productive, and the Valdor Dredging Co. commenced working its 7-cubic-foot dredge in the Trinity River, 4 miles below Junction City, in November, 1916. The largest hydraulic producer at Lewiston was the Bablew Mines Co., and others were the Donnelly Gulch Mining Co., Phillips, and Trinity River Mining Co. The Trinity Dredge Co. operated its dredge in Trinity River near this place. The only mine reporting from Minersville was that of the Humboldt Placer Mining Co. and the only one reporting from Peanut was the Mistake No. 1. At Ruth a small yield was obtained by the Linda Marie hydraulic mine. The Alta Bert Dredge Co. worked most of the year at Trinity Center. Near Weaverville the La Grange Mining Co. operated its extensive hydraulic mine, and the Horseshoe hydraulic hydraulicked surface gravel near the same place. The Gem placer operated in a small way at Willow Creek.

## TUOLUMNE COUNTY.

In Tuolumne County in 1916 there was a decrease of 4 in the number of productive mines and a decrease in output of quantity of ore and in value of gold. The output of gold was 42,000.96 fine ounces, valued at $868,237, and of silver, 25,895 fine ounces, valued at $17,039. The total value for the year was $885,276, a decrease of $186,832. The deep mines of the county produced 225,065 tons of ore which yielded 41,530.32 fine ounces of gold, valued at $858,508, and 25,649 ounces of silver, valued at $16,877, a total metal value from deep mines of $875,385, as compared with $1,067,631 in 1915. There were 23 producing mines in the county in 1916, of which 4 were placers and 19 were deep gold mines. The 3 drift mines and 1 surface placer yielded 470.64 fine ounces of gold, valued at $9,729, and 246 fine ounces of silver, valued at $162, a total yield of $9,891.

The quantity of ore sold or treated in the county in 1916 amounted to 225,065 tons, or 23,877 tons less than in 1915. Of the 225,065 tons, 223,206 tons were treated in gold and silver mills and yielded $485,529 in gold bullion and 22,514 fine ounces of silver, valued at $14,814, a total average in mill bullion of $500,343, or an average of $2.24 a ton in gold and silver. From the milling ore 9,949 tons of concentrates were obtained, which yielded $366,737 in gold and 749 fine ounces of silver, valued at $493, a total of $367,230 in gold and silver, and a total average yield of $36.91 per ton.

The ore milled and concentrated yielded a total value of $852,266 in gold and $15,307 in silver. The total yield of gold and silver on the plates and from the concentrates was valued at $867,573, or $3.88 a ton, as compared with $4.28 a ton in 1915.

In addition 14 tons of ore were sent to smelters and yielded $186 in gold and $1 in silver, a total value of $187, or an average value of $13.36 a ton.

The only producing deep mine reporting from Big Oak Flat was the Gold Boy and Little Wonder, and from Chinese the C. & P. Mining Co. reported a small output. The Experimental Gulch mine, at Columbia, is developed by a 300-foot vertical shaft and an adit 2,400 feet long. The owners worked through the tunnel for four months, running the 5-stamp mill, and then worked four months through the shaft running the 3-stamp mill. The Over and the Oregon & Crackerjack mines, also at Columbia, made some output. Some gold was obtained from the Carlin mine, at Jamestown, by crushing high-grade rock in a hand mortar. The Harvard Mines (Inc.), at the same place, is opened by a 750-foot vertical shaft and a 1,100-foot incline shaft. The equipment consists of a 60-stamp amalgamation and concentration mill. The mine and plant were in operation all the year to November 1, but the property was then closed indefinitely. Mostly development work was done on the Josephine, but a small yield was obtained. The Dutch-Sweeney and App mines are operated as one property and are opened by two incline shafts 1,800 feet and 1,300 feet deep. The equipment consists of a 40-stamp amalgamating and concentrating mill, two Hardinge mills, a tube mill, and a flotation plant. The property of the Eagle-Shawmut Mining Co., at Shawmut, is opened by an adit 2,000 feet long and an incline shaft of 1,817 feet at end of the adit. The equipment consists of a 100-stamp amalgamation and concentration

mill, of which 40 stamps and 24 concentrators were used in 1916. There are also chlorination works of 40-ton capacity. The Hope Mining & Development Co., near Sonora, is equipped with a 5-stamp mill and was worked continuously during 1916. There are several productive small mines in the same vicinity. The Black Oak mine, at Soulsbyville, is developed through an incline shaft 1,800 feet deep. The reduction is accomplished by a 90-ton continuous agitation all-sliming plant. The ore is crushed by a 20-stamp mill, reground by tube mill, classified, agitated, thickened, and filtered. The property of the Jumper-California Gold Mining Co., at Stent, was operated continuously in 1916 by lessees. The mine is developed by an incline shaft 1,400 feet deep, and a winze to 1,800 feet, and several miles of drifts and crosscuts. The equipment consists of a 20-stamp amalgamating mill. The Nyman Consolidated Mines Co., also at Stent, is opened by two incline shafts 800 feet deep and one vertical shaft 850 feet deep. About 15,000 feet of lateral development work has been done on the property. The equipment consists of a 40-stamp amalgamation and concentration mill. The Sunny South and the New Providence Consolidated Mining Co. are small producers at Tuolumne. The Star King and Sherman, at the same place, had development work done on a small scale and made some output. The equipment consists of a 5-stamp amalgamation and concentration mill. At Tuttletown the Atlas Consolidating Mining Co. made a nominal output.

Of the placers in the county the Saratoga is a drift mine producing at Columbia, and the Stanislaus Gravel Mining Co. made some production near Jamestown. Several small placers reported some yield at both these places.

## YUBA COUNTY.

Yuba County in 1916 held the same relative rank among gold-producing counties as it did in 1915, being exceeded only by Nevada and Amador counties, both of which are deep-mine regions. Yuba County in 1916 produced more placer gold than any other county in the State, mainly through dredging operations. The output of Yuba County in 1916 was $3,167,723 in gold and 9,018 fine ounces of silver, valued at $5,934, a total of $3,173,657, and an increase of $464,693 as compared with 1915. The dredges in 1916 produced $3,140,150 in gold, which is $464,060 more than in 1915. Thirteen dredges operated in the county in 1916, and, including these dredges, there were 23 productive placers and only one deep mine.

The Yuba Consolidated Goldfields, operated by the Hammon Engineering Co., is the largest dredging enterprise and worked 10 dredges in 1916, the newer ones being the largest ever constructed. The Marysville Dredging Co. operated three dredges on the Yuba River, at Marigold. Both these companies recovered considerable platinum with their gold. Other placers in the county which produced during the year were the Bright Star and Landers Bar, at Browns Valley; Snowden Hill, at Camptonville; Archimedes and Mammoth, at Marysville; and Julius Caesar, at Smartsville. Unimportant placers operated productively at Dobbins, Marysville, Smartsville, and Woodleaf.

## OTHER COUNTIES.

*Fresno County.*—This county produced in 1916 metals valued at $8,006, of which $693 was gold; and there were 105 ounces of silver, valued at $69, and 29,447 pounds of copper, valued at $7,244. The producing mines were the Copper King Operating Co. and the Imperial Copper Co., at Clovis, and the Sunnyside Gold Mining Co., at Piedra. The last company is equipped with a 5-stamp mill and cyanide plant.

*Imperial County.*—This county produced $23,338 in gold; 235 fine ounces of silver, valued at $155; 6,045 pounds of copper, valued at $1,487; and 18,304 pounds of lead, valued at $1,263, the total metal value being $26,243. The First Chance mine, at Ogilby, supplied ore to the Copper Queen smelter, at Douglas, Ariz. The Queen mine of the Danube Mining Co. is at Ogilby, but has no mill. The Marcella is a copper mine at Niland.

*Merced and Stanislaus counties.*—In these counties there were three dredges, one surface placer, and one copper mine operating in 1916, the combined total output from which was $276,817, of which $271,616 was gold.

*Modoc County.*—This county produced $2,729 in gold and 137 ounces of silver, valued at $90, a total of $2,819. The only two mines reporting product were the Big Four and the Eugene, at Fort Bidwell.

# GOLD, SILVER, COPPER, AND LEAD IN OREGON.

(MINES REPORT.)

By CHARLES G. YALE.

## INTRODUCTION.

After several years of depression the total metal output of Oregon increased in value nearly 47 per cent in 1916, as compared with 1915. This increase was mainly due to copper, but the increase in gold and silver had its influence also. Aside from the copper, the deep mines of the State did not make as large a production as in 1915, but the deficiency of gold from that source was much more than made up by the yield from placers in 1916. This marked placer-mine increase was mainly from the dredges, there being now three in operation. There were only a few more mines in operation in Oregon in 1916 than in 1915 and one formerly large producer among the deep mines ceased operations altogether at the end of 1916. The average value of the siliceous ore obtained from the deep mines declined nearly a dollar a ton in 1916, as compared with 1915, and the quantity treated or sold was about the same each year, which accounts for the falling off in the gold yield of the deep mines in the State.

Aside from the gold dredging operations and a few hydraulic properties, there are not many large mining enterprises being carried on in Oregon. Of the deep mines exceeding $100.000 each in annual output may be enumerated the Homestead Iron Dyke, Baker Mines Co., Commercial Mining Co. (Rainbow), and Cornucopia Mines Co. of New York, all in Baker County; and the Queen of Bronze, in Josephine County.

The southwestern counties of Oregon,[1] which form an extension of the California gold belt, are Benton, Coos, Curry, Douglas, Jackson, Josephine, and Lane. These counties (with the exception of Benton and Coos, from which no product was reported) made in 1916 a combined production of $172,289 in gold, and 15,498 ounces of silver, valued at $10,198. The production of placer gold in this region in 1916 was $131,327, an increase of $32,663, and the production of gold from deep mines was $40,962, an increase of $11,410. The total increase in output of gold in these southwestern counties in 1916, as compared with 1915, was therefore, $44,073.

[1] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 9–127, 1914; Diller, J. S., and Kay, G. F., Mines of the Riddles quadrangle, Oreg.: U. S. Geol. Survey Bull. 340, pp. 134–152, 1908.

Northeastern Oregon comprises the counties of Baker, Crook, Grant, Harney, Malheur, Umatilla, Union, Wallowa, and Wheeler. In 1916 the counties of Harney, Umatilla, Union, and Wallowa had no metallic output. The combined gold output of the five producing counties of this region in 1916 was $1,728,217, of which Baker County contributed $1,640,626, or 95 per cent. There was a decrease for 1916 of these counties, as compared with 1915, of $3,946. The yield of placer gold in 1916 was $741,190, an increase of $357,684, or 93 per cent. The lode mines produced in gold $987,027 in 1916, as compared with $1,348,657 in 1915, a decrease of $361,630, or 27 per cent.

The remainder of the gold production of Oregon was derived from Marion County.

## PRODUCTION.

### GENERAL STATEMENT.

*Gold, silver, copper, and lead produced in Oregon, 1907–1916.*

| Year. | Number of mines producing. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine oz.* | *Pounds.* | *Pounds.* | |
| 1907 | 206 | 110,698. | $1,129,261 | 86,718 | 554,104 | ..... | $1,297,316 |
| 1908 | 239 | 50,684 | 865,076 | 43,602 | 291,377 | 2,138 | 926,737 |
| 1909 | 162 | 59,281 | 781,964 | 27,827 | 235,000 | 400 | 827,001 |
| 1910 | 180 | 82,132 | 679,488 | 35,978 | 13,861 | ..... | 700,676 |
| 1911 | 176 | 98,558 | 633,407 | 45,221 | 93,136 | ..... | 669,016 |
| 1912 | 210 | 90,945 | 770,041 | 57,081 | 260,429 | 39,317 | 849,886 |
| 1913 | 173 | 155,901 | 1,627,710 | 179,036 | 43,330 | 87,207 | 1,746,402 |
| 1914 | 105 | 124,331 | 1,591,461 | 142,552 | 39,248 | 16,436 | 1,676,153 |
| 1915 | 95 | 155,791 | 1,861,796 | 117,947 | 451,172 | 62,957 | 2,003,509 |
| 1916 | 108 | 159,071 | 1,902,179 | 231,342 | 3,581,886 | 28,000 | 2,937,478 |
| Increase or decrease, 1916.. | +13 | +3,280 | +40,383 | +113,395 | +3,130,714 | −34,957 | +933,969 |

The total metal yield of Oregon increased in value $933,969 in 1916, as compared with 1915. The quantity of ore increased 2.1 per cent; the gold increased 2.17 per cent; the silver increased 96 per cent; the copper increased 694 per cent; and the lead decreased 56 per cent.

The mine production of Oregon, having a total value of $2,937,478 in 1916, was derived from 108 producing mines, of which 75 were placer and 33 were deep. The producing placers increased by 10 in 1916 and the producing deep mines by 3. The total quantity of ore sold or treated was 159,071 tons, an increase of 3,280 tons. This averaged $7.39 a ton in gold and silver, aside from copper and lead.

### GOLD.

The total recoverable gold content of ores and the gold from placers in Oregon in 1916 was 92,017.91 fine ounces, valued at $1,902,179, an increase of 1,953.53 fine ounces in quantity and of $40,383 in value. The largest yield of gold from one county, valued at $1,640,626, came as usual from Baker County and was a decrease of $44,756, as compared with the yield in 1915. The next county in rank was Josephine, with $94,481, or an increase of $9,399. Other counties in rank of production of gold were Grant, Jackson, Douglas, Malheur, Crook, Curry, Lane, Marion, and Wheeler. The placer

mines of the State produced $872,517 in gold in 1916, as compared with $482,170 in 1915, an increase of $390,347. The hydraulic mines produced $164,548 in 1916, or $49,535 more than in 1915; the drift mines, $4,432, or $2,366 more; the surface placers and dredges combined, $703,537, or $338,446 more. There were 61 productive hydraulic mines in 1916, as compared with 52 in 1915; and 5 drift and 6 surface placer mines were productive in 1916.

The total output of gold from deep mines was 49,809.90 fine ounces, valued at $1,029,662, which was 16,929.51 ounces less in quantity and $349,964 less in value than in 1915. Of the gold derived from deep mines $390,284 was recovered by amalgamation and $547,675 by cyanidation. In Oregon there were no chlorination plants and the concentrates obtained were shipped generally to smelters for treatment.

*Mine production of gold in Oregon in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | Grand total. |
|---|---|---|---|---|---|---|
| | | Siliceous ore. | Copper ore. | Lead ore. | Total. | |
| Baker | 32,027.88 | 46,561.71 | 775.69 | ..... | 47,337.40 | 79,365.28 |
| Crook | 187.60 | 236.99 | ..... | ..... | 236.99 | 424.59 |
| Curry | 337.03 | ..... | ..... | ..... | ..... | 337.03 |
| Douglas | 1,122.54 | 27.96 | 37.83 | ..... | 65.79 | 1,188.33 |
| Grant | 2,903.27 | 168.06 | 4.98 | ..... | 173.04 | 3,076.31 |
| Jackson | 1,765.25 | 313.37 | ..... | ..... | 313.37 | 2,078.62 |
| Josephine | 3,128.12 | 107.01 | 1,335.39 | ..... | 1,442.40 | 4,570.52 |
| Lane | ..... | ..... | ..... | 159.98 | 159.98 | 159.98 |
| Malheur | 690.60 | ..... | ..... | ..... | ..... | 690.60 |
| Marion | ..... | ..... | 80.93 | ..... | 80.93 | 80.93 |
| Wheeler | 45.72 | ..... | ..... | ..... | ..... | 45.72 |
| | 42,206.01 | 47,415.10 | 2,234.82 | 159.98 | 49,809.90 | 92,017.91 |
| Increase or decrease | +18,883.04 | −19,158.29 | +2,151.81 | +76.97 | −16,929.51 | +1,953.53 |

*Value of output of placer gold in Oregon in 1916.*

| County. | Hydraulic. | Drift. | Dredging. | Surface placers. | Total. |
|---|---|---|---|---|---|
| Baker | $9,961 | $2,551 | [a] $670,450 | $30,090 | $713,052 |
| Crook | 3,878 | ..... | ..... | ..... | 3,878 |
| Curry | 5,830 | ..... | ..... | 1,137 | 6,967 |
| Douglas | 23,102 | ..... | ..... | 103 | 23,205 |
| Grant | 9,039 | ..... | ..... | ..... | 9,039 |
| Jackson | 36,284 | 207 | ..... | ..... | 36,491 |
| Josephine | 62,845 | 1,674 | ..... | 145 | 64,664 |
| Malheur | 12,664 | ..... | ..... | 1,612 | 14,276 |
| Wheeler | 945 | ..... | ..... | ..... | 945 |
| | 164,548 | 4,432 | 670,450 | 33,087 | 872,517 |

[a] Includes dredging in Grant County.

## SILVER.

The recoverable silver content of ores and the silver from placers in Oregon in 1916 aggregated 231,342 fine ounces, valued at $152,223, an increase of 113,395 ounces in quantity and of $92,424 in value. Baker County in 1916 made the largest output of silver, 213,483 fine ounces, valued at $140,472. Josephine County produced 14,966 ounces, valued at $9,848. The placer mines of Oregon produced 9,249 fine ounces, valued at $6,086, as compared with 5,527 ounces,

valued at $2,802 in 1915. The deep mines produced 222,093 fine ounces, valued at $146,137; of this quantity 103,822 ounces were derived from copper ores, and 128 ounces from lead ores, the remainder, 118,143 ounces, being derived from siliceous ore. Most of the silver derived from deep mines, 103,822 ounces, came from the smelting of the copper ores. By amalgamation 74,416 ounces were recovered and 31,476 ounces by cyanidation.

*Mine production of silver in Oregon in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | Grand total. |
|---|---|---|---|---|---|---|
| | | Siliceous ore. | Copper ore. | Lead ore. | Total. | |
| Baker | 8,076 | 116,182 | 89,225 | ..... | 205,407 | 213,483 |
| Crook | 46 | 628 | ..... | ..... | 628 | 674 |
| Curry | 30 | ..... | ..... | ..... | ..... | 30 |
| Douglas | 99 | 22 | 12 | ..... | 34 | 133 |
| Grant | 315 | 1,276 | 8 | ..... | 1,284 | 1,599 |
| Jackson | 220 | 21 | ..... | ..... | 21 | 241 |
| Josephine | 384 | 14 | 14,568 | ..... | 14,582 | 14,966 |
| Lane | ..... | ..... | ..... | 128 | 128 | 128 |
| Malheur | 71 | ..... | ..... | ..... | ..... | 71 |
| Marion | ..... | ..... | 9 | ..... | 9 | 9 |
| Wheeler | 8 | ..... | ..... | ..... | ..... | 8 |
| | 9,249 | 118,143 | 103,822 | 128 | 222,093 | 231,342 |
| Increase or decrease | +3,722 | +18,879 | +94,015 | −3,221 | +109,673 | +113,395 |

## COPPER.

The mine production of copper in Oregon in 1916 was 3,581,886 pounds, valued at $881,144, as compared with 451,172 pounds in 1915, valued at $78,955, an increase for 1916 of 3,130,714 pounds in quantity and of $802,189 in value.

## LEAD.

In 1916 Oregon produced 28,000 pounds of lead, valued at $1,932, as compared with 62,957 pounds, valued at $2,959, in 1915. Lead was produced in the counties of Lane and Josephine, the larger quantity coming from Lane County.

## MINING INDUSTRY.

*Gold and silver produced in Oregon in 1916.*

| County. | Ore to gold and silver mills. | | | Concentrates produced. | | |
|---|---|---|---|---|---|---|
| | Quantity. | Gold. | Silver. | Quantity. | Gold. | Silver. |
| | *Short tons.* | | *Fine ounces.* | *Short tons.* | | *Fine ounces.* |
| Baker | 120,171 | $931,533 | 105,869 | 2,337 | $32,182 | 18,650 |
| Grant | 860 | 270 | 26 | 134 | 3,204 | 1,251 |
| Jackson | 2,099 | 3,540 | 12 | 60 | 900 | 1 |
| Josephine | 102 | 2,212 | 14 | ..... | ..... | ..... |
| | 123,232 | 937,555 | 105,921 | 2,531 | 36,286 | 19,902 |
| Average per ton | ..... | $7.61 | 0.859 | ..... | $14.34 | 7.86 |

*Gold and silver produced in Oregon in 1916*—Continued.

| County. | Crude ore to smelter. | | |
|---|---|---|---|
| | Quantity. | Gold. | Silver. |
| | *Short tons.* | | *Fine ounces.* |
| Baker | 23,958 | $14,836 | 80,888 |
| Crook | 169 | 4,899 | 628 |
| Douglas | 20 | 1,360 | 34 |
| Grant | 14 | 103 | 7 |
| Jackson | 207 | 2,038 | 7 |
| Josephine | 11,382 | 27,605 | 14,569 |
| Lane | 49 | 3,307 | 128 |
| Marion | 40 | 1,673 | 9 |
| | 35,839 | 55,821 | 96,270 |
| Average per ton | ..... | $1.56 | 2.69 |

There were treated at gold and silver mills in 1916 in Oregon 123,232 tons of ore, yielding $973,841 in gold, and 125,823 ounces of silver valued at $82,792. In milling the ore at gold and silver mills $937,555 in gold and 105,921 fine ounces of silver were recovered by amalgamation and cyanidation. From these 123,232 tons of milling ore were recovered 2,531 tons of concentrates, having a value in gold of $36,286 and 19,902 ounces of silver, valued at $13,096, a total of $49,382. Crude ore shipped to smelters amounted to 35,839 tons and contained $55,821 in gold and 96,270 ounces of silver. The 49 tons of purely lead ores shipped to the smelters yielded in lead 16,348 pounds, or 334 pounds a ton. The 35,409 tons of copper ore shipped to smelters yielded 3,580,496 pounds of copper, or an average of about 101 pounds a ton. There were no old tailings treated in Oregon in 1916.

*Ore sold or treated in Oregon in 1916, in short tons.*

| County. | Siliceous ore. | Copper ore. | Lead ore. | Total ore. |
|---|---|---|---|---|
| Baker | 120,171 | 23,958 | ..... | 144,129 |
| Crook | 169 | ..... | ..... | 169 |
| Douglas | 5 | 15 | ..... | 20 |
| Grant | 860 | 14 | ..... | 874 |
| Jackson | 2,306 | ..... | ..... | 2,306 |
| Josephine | 102 | 11,382 | ..... | 11,484 |
| Lane | ..... | ..... | 49 | 49 |
| Marion | ..... | 40 | ..... | 40 |
| | 123,613 | 35,409 | 49 | 159,071 |
| Increase or decrease | −27,463 | +31,687 | −944 | +3,280 |
| Value per ton in gold and silver | $8.56 | $3.23 | $69.20 | $7.39 |

*Mine production of gold, silver, copper, and lead in Oregon in 1916.*

| County. | Ore. | Quartz gold. | | Placer gold. | | Total. | | Quartz silver. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | | *Fine ounces.* | | *Fine ounces.* | |
| Baker | 144,129 | 47,337.40 | $978,551 | 32,027.88 | $662,075 | 79,365.28 | $1,640,626 | 205,407 | $135,158 |
| Crook | 169 | 236.99 | 4,899 | 187.60 | 3,878 | 424.59 | 8,777 | 628 | 413 |
| Curry | | | | 337.03 | 6,967 | 337.03 | 6,967 | | |
| Douglas | 20 | 65.79 | 1,360 | 1,122.54 | 23,205 | 1,188.33 | 24,565 | 34 | 22 |
| Grant | 874 | 173.04 | 3,577 | 2,903.27 | 60,016 | 3,076.31 | 63,593 | 1,284 | 845 |
| Jackson | 2,306 | 313.37 | 6,478 | 1,765.25 | 36,491 | 2,078.62 | 42,969 | 21 | 14 |
| Josephine | 11,484 | 1,442.40 | 29,817 | 3,128.12 | 64,664 | 4,570.52 | 94,481 | 14,582 | 9,595 |
| Lane | 49 | 159.98 | 3,307 | | | 159.98 | 3,307 | 128 | 84 |
| Malheur | | | | 690.60 | 14,276 | 690.60 | 14,276 | | |
| Marion | 40 | 80.93 | 1,673 | | | 80.93 | 1,673 | 9 | 6 |
| Wheeler | | | | 45.72 | 945 | 45.72 | 945 | | |
| | 159,071 | 49,809.90 | 1,029,662 | 42,208.01 | 872,517 | 92,017.91 | 1,902,179 | 222,093 | 146,137 |

| County. | Placer silver. | | Total silver. | | Copper. | | Lead. | | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Fine ounces.* | | *Fine ounces.* | | *Pounds.* | | *Pounds.* | | |
| Baker | 8,076 | $5,314 | 213,483 | $140,472 | 2,631,727 | $647,405 | | | $2,428,503 |
| Crook | 46 | 30 | 674 | 443 | | | | | 9,220 |
| Curry | 30 | 20 | 30 | 20 | | | | | 6,987 |
| Douglas | 99 | 65 | 133 | 87 | 1,939 | 477 | | | 25,129 |
| Grant | 315 | 207 | 1,599 | 1,052 | 1,204 | 296 | | | 64,941 |
| Jackson | 220 | 145 | 241 | 159 | | | | | 43,128 |
| Josephine | 384 | 253 | 14,966 | 9,848 | 939,122 | 231,024 | 11,652 | $804 | 336,157 |
| Lane | | | 128 | 84 | 1,390 | 342 | 16,348 | 1,128 | 4,861 |
| Malheur | 71 | 47 | 71 | 47 | | | | | 14,323 |
| Marion | | | 9 | 6 | 6,504 | 1,600 | | | 3,279 |
| Wheeler | 8 | 5 | 8 | 5 | | | | | 950 |
| | 9,249 | 6,086 | 231,342 | 152,223 | 3,581,886 | 881,144 | 28,000 | 1,932 | 2,937,478 |

## PRODUCTION BY COUNTIES.

### BAKER COUNTY.

The total value of all metals mined in Baker County in 1916 was $2,428,503, as compared with $1,810,796 for 1915, an increase of $617,707. This was due principally to the production of copper, which increased 2,234,624 pounds in quantity and $577,912 in value in 1916, as compared with 1915. The production of gold from deep mines in 1916 decreased $342,923, silver increased 103,359 ounces, and lead decreased 1,872 pounds in quantity and $88 in value. The total increase in all metals from the deep mines in 1916, as compared with 1915, was $316,528. The placer mines of the county produced $662,075 in gold in 1916, an increase of $298,167. The placer silver produced in 1916 was 8,076 ounces, valued at $5,314, an increase in value of $3,012. There were 27 producing mines in the county in 1916, as compared with 26 in 1915. The number of producing deep mines was 13 and of placer mines 14. The total output of siliceous ore mined and treated in the county in 1916 was 120,171 tons, or 19,991 tons less than in 1915. The gold from this ore was valued at $962,516 and the silver amounted to 116,182 fine ounces, valued at $76,448. The average recoverable value of the ore per ton in gold and silver was $8.65.

The 120,171 tons of siliceous ore was all treated at gold and silver mills and produced $931,533 in gold and 105,869 fine ounces of silver (valued at $69,662) by amalgamation and cyanidation, an average per ton of $8.33 in gold and silver. From the 120,171 tons of milling ore were derived 2,337 tons of concentrates producing $32,182 in gold and 18,650 ounces of silver (valued at $12,272) a total value of $44,454, or an average value per ton of $19.02. The total yield of the 120,171 tons of milling ore from the plates, from direct cyanidation, and from the concentrates was $963,715 in gold and $81,934 in silver, an average per ton of $8.69. In addition 23,958 tons of ore were shipped to smelters, yielding in gold $14,836 and in silver 80,888 ounces, valued at $53,224, a total value of smelting ores of $68,060 in gold and silver, or an average per ton of $2.84, not considering copper. No old tailings were treated in Baker County in 1916.

*Baker district.*—There were two productive placer mines in this district in 1916, their combined output in gold and silver being $11,939 more than in 1915. No deep mines reported product from the district in 1916.

*Cornucopia district.*—This is no longer the most productive district in Oregon, as it was in 1915, being exceeded in total output in 1916 by both Cracker Creek and Iron Dyke districts. Still the four deep mines of the district produced $617,425 in gold and silver, of which $551,325 was gold. The most important mine in the district is that of the Baker Mines Co., which is developed through three adits and is equipped with a 20-stamp mill, tube mill, and cyanide plant. The mine and mill have been continuously operated since the beginning of operations late in 1914. The mine of the Cornucopia Mines Co., of New York, another large producer, is developed by two underground shafts, 500 and 700 feet deep, the adit to the shafts being 1,400 feet long. The mine is equipped with a 20-stamp mill,

tube mills, and 120-ton cyanide plant. The property of the Queen of the West Mines Co. is equipped with a 10-stamp mill and with concentrators and a cyanide plant. The new 50-ton cyanide plant and wire-rope tramway was built in 1916. The Bonanza Mining Co. mines were idle in 1916. The Connor Creek Mining & Milling Co., near Home, in this district, was a producer and is now equipped with a new 10-stamp mill, built in 1917.

*Cracker Creek district.*—Next to Iron Dyke, this was the most productive district in Baker County and in the State in 1916. There are two hydraulic mines, one drift, and two dredges in operation, which made a combined output of $627,137 in gold and silver. The two deep mines in the district produced $81,711 in gold and silver. Of these latter the mine of the Columbia Gold Mining Co., at Sumpter, was the most productive, and is equipped with a 20-stamp amalgamation and concentration mill, rolls, and a 60-ton cyanide plant. This property was permanently closed in November, 1916. The Whited Mining Co., at the same place, is new on the list of deep-mine producers. The hydraulic mines in the district are the Clark Creek Farm, at Bridgeport, and Buck Gulch, at Sumpter. The Surprise is a drift mine, at Bridgeport. The largest placer operator in the district and in the State is the Powder River Dredge Co., which has two dredges at work on stream gravel.

*Granite district.*—The Snyder Consolidated Gold Mining Co. operates a drift mine in this district, between Park Creek and Quicksilver Creek.

*Iron Dyke district.*—In this district is located the property of the Homestead Iron Dyke Mines Co., the most productive in Oregon. Most of the values recovered are in copper, but there is also an output of gold and silver. A concentrator with a capacity of 150 tons daily was completed in 1916 and the flotation process is in use. The other productive mine in the district is the Arkansas.

*Mormon Basin district.*—The most important property in this district is the Rainbow mine of the Commercial Mining Co., one of the few large deep producers of the State. This is opened by a 400-foot vertical shaft, an adit 1,500 feet long, and 3,700 feet of drifts and crosscuts. A 100-foot winze was sunk from the 400-foot level in 1916. The equipment is a 100-ton cyanide plant, including 15 stamps and amalgamation apparatus. The Deek Creek and May Queen and the Orion mines produced in this district also, the last being equipped with a small portable test mill, erected in 1916. A 10-stamp mill has been installed since the close of the year. The Rye Valley Placers hydraulic mine was operating productively in this district.

*Pine Creek district.*—The productive hydraulic mines in this district were the Bull Dog, Cow Creek, and Hamm Mining Co., and the productive drift mine was that of the Huntington Mining Co.

*Weatherby district.*—The Little Hill mine in this district is equipped with a 2-stamp mill, and the Pinto is also operating in a small way.

### CLACKAMAS, CROOK, AND CURRY COUNTIES.

No production was reported from Clackamas County in 1916. Crook County produced a total of $9,220 in gold and silver in 1916

from 1 deep mine and 1 hydraulic placer mine. Curry County, from 3 hydraulic mines, the Horseshoe Bend, Cheney, and Merrill, and 1 surface placer mine, the Myrtle, produced $6,987 in gold and silver.

### DOUGLAS COUNTY.

There was an increase of $22,707 in the production of metals in Douglas County in 1916. Myrtle Creek was the most important district and had a production of $21,267 in gold and silver. Some copper ore was shipped from the Riddle district. The greater part of the output—$23,205 in gold and $65 in silver—came from the placer mines of the county. These were the Bowlder, Hogan or Booth, Buck Fork, and Red Bell hydraulics, and the Starvout Nugget placer. The productive deep mines of the county were the Hall and Noonday, both of which supplied ore to a smelter.

### GRANT COUNTY.

There was a large increase in the output from this county in 1916, due mostly to the new dredge of the Empire Gold Dredge Co., at John Day, in the Canyon district. The total production for the county in 1916 was $63,593 in gold, 1,599 ounces of silver, valued at $1,052, and 1,204 pounds of copper, valued at $296, or a total of $64,941. The deep mines producing were the Gem and Ben Harrison, the latter of which is extensively developed and is equipped with a 20-stamp mill and concentration and flotation plant. The hydraulic mines producing were the Caledonia, Quartz Gulch, O'Dair, and Onion Creek.

### JACKSON COUNTY.

There were 3 producing deep mines in Jackson County and 10 placers, or 2 more than in 1915. One drift and 9 hydraulic mines made a combined production in gold and silver of $36,636. The principal mines were the Layton, in Applegate district; Blue Ridge, Spaulding, and Sterling, in Forest Creek district; and Duffield & Burns and Galls Creek, in Galls Creek district. The producing deep mines were the Grubstake, in Blue Ledge district; the Opp, in Jacksonville district; the Pearl, in Pearl district; and the Gold Ridge, in Kanes Creek district. These deep mines in the county made a combined output of gold and silver of $6,492 in 1916. The total output of the county in gold and silver in 1916 was $43,128.

### JOSEPHINE COUNTY.

The total output of gold, silver, copper, and lead in Josephine County in 1916 was valued at $336,157, as compared with $98,998 in 1915, an increase of $237,159, due mostly to the increased production of copper in 1916. The gold yield was $94,481; the silver was 14,966 ounces, valued at $9,848. The 8 deep mines of the county produced from 11,484 tons of ore, $29,817 in gold; 14,582 ounces of silver,

valued at $9,595; 939,122 pounds of copper, valued at $231,024; and 11,652 pounds of lead, valued at $804. The total value of the deep-mine product of the county was therefore $271,240. Of the total output of placer gold of $64,664, the hydraulic mines produced $62,845; the remainder was derived from small drift and surface placers. The decrease in placer gold in the county in 1916 was $5,635. The increase in total production of gold for 1916, as compared with 1915, was $9,399. Of the 11,484 tons of ore produced in the county, 102 tons were treated at gold and silver mills, and 11,382 tons were shipped to smelters.

The producing hydraulic mines in Althouse district were the Goldsby and Smock, both at Holland.

In Galice district the few producing placers are small and unimportant. The property of the Almeda Consolidated Mines Co., quite extensively developed, is equipped with a 100-ton capacity water-jacket smelting furnace. The ores, in addition to copper, carry considerable gold and silver. The Mayflower is another productive deep mine in this district, but was worked in a small way.

The three hydraulic mines operating in Grave Creek district were the Archer, Goff-Abbott, and Norton.

Four deep and four placer mines reported production from Josephine district in 1916. The combined output of the placers, all hydraulic, was $13,302 in gold and a nominal quantity of silver. The largest producer was the Anderson mine, at Kerby, the others being the Canyon Creek-Butler and the Gold Leaf group. The water season was short and none of the mines obtained normal output. The most prominent deep mine in the district is the Queen of Bronze, of the Takilma Smelting Co., which is developed by tunnels and drifts aggregating 6,500 feet in length. The ore is shipped to the Tacoma smelter. The values recovered were from copper and silver. The St. Lily and the Diamond Drill made a small output of copper at Takilma. Other deep-mine producers were the Waldo Copper Co. and the Cowboy mine of the Waldo Smelting & Mining Co.

In Jump Off Joe district the productive mines were all hydraulic, including the Cook & Howland, McCullough, Ohio No. 5, Swastika, and Sexton.

In Placer district the only productive deep mine was that of the Atlantic Copper Co., and the only productive placer was the hydraulic mine owned by the Columbia Mines Co., quite a large producer.

Pickett Creek district has only a few unimportant hydraulic mines. In Sucker Creek district the January First is a small deep mine, the ore of which was worked in an arastre. In Waldo district are the Deep Gravel and Osgood hydraulic mines. There are a few small placers in Williams district, and the Blue Channel hydraulic was operated in Wolf Creek district.

### MALHEUR COUNTY.

Malheur County had six producing hydraulic mines, the Glengarry, the Boswell, the Hope, the White, and the Quartz Gulch at Malheur Basin, and the Colt Placers at Mormon Basin. The Hope Consolidated, a deep mine formerly producing, was closed down.

### LANE, MARION, UNION, AND WHEELER COUNTIES.

In Lane County one deep mine, the West Coast, at Bohemia, produced some lead ore during 1916. In Marion County the Consolidated Copper mine, at Elkhorn, produced a small quantity of copper ore during the year. Two hydraulic placer properties reported a small production from Wheeler County. No production was reported from Union County.

# GOLD, SILVER, AND LEAD IN SOUTH DAKOTA.

(MINES REPORT.)

By CHARLES W. HENDERSON.

## PRODUCTION.

The total value of the production of gold, silver, and lead in South Dakota in 1916 was $7,604,692, an increase of $96,910. The output of gold was 360,908.65 fine ounces, valued at $7,460,644, more than 98 per cent of the total value. The increase in the yield of gold for the year was only 2,628.65 fine ounces in quantity and $54,339 in value. The production of silver increased from 199,864 fine ounces to 215,205 fine ounces and the value from $101,331 to $141,605. Smelting ore from South Dakota carried 35,406 pounds of lead. The yield of placer gold amounted to 102.12 fine ounces. There were 45 producing mines, of which 29 were deep and 16 were placer, an increase of 6 deep and 6 placer mines, as compared with 1915.

The total quantity of ore mined and treated in 1916 was 1,870,783 short tons, averaging in recovered gold 0.1929 ounce, or $3.99 per ton, as compared with 1,889,975 short tons averaging $3.92 in 1915. There were 1,870,249 tons of ore treated in the mills of the State, yielding as bullion $7,437,332 in gold and 212,779 fine ounces of silver, valued at $140,009, an average recovery per ton of $3.98 in gold and 0.11 ounce in silver, as compared with $3.90 in gold and 0.10 ounce in silver in 1915. In addition, in 1916 the ore treated yielded a small quantity of concentrates carrying gold and silver. The quantity of crude ore shipped to smelters was 534 tons having an average content of 1.707 fine ounces, or $35.28, in gold and of 4.46 ounces of silver a ton.

*Gold and silver produced at mills in South Dakota in 1916.*

| Process. | Ore to gold and silver mills. | Gold in bullion. | Silver in bullion. |
|---|---|---|---|
| | *Short tons.* | *Fine ounce.* | *Fine ounce.* |
| Amalgamation | 1,600,320 | 228,760.76 | 69,963 |
| Cyanidation | a1,782,326 | 131,020.18 | 142,816 |
| | 3,382,646 | 359,780.94 | 212,779 |

a Includes 1,512,397 tons of tailings from part of ore amalgamated.

The consumption of quicksilver and cyanide in South Dakota mills in 1916 was 12,516 pounds of quicksilver,[1] 5,300 pounds of potassium cyanide,[2] and 419,210 pounds of sodium cyanide.[2]

*Mine production of gold, silver, and lead in South Dakota in 1915 and 1916.*

| Year. | Number of mines producing. | Ore. | Gold.[a] | | Silver.[a] | | Lead. | | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | | *Pounds.* | | |
| 1915 | 33 | 1,889,975 | 358,280.00 | $7,406,305 | 199,864 | $101,331 | 3,107 | $146 | $7,507,782 |
| 1916 | 45 | 1,870,783 | 360,908.65 | 7,460,644 | 215,205 | 141,605 | 35,406 | 2,443 | 7,604,692 |
| Increase or decrease | +12 | −19,192 | +2,628.65 | +54,339 | +15,341 | +40,274 | +32,299 | +2,297 | +96,910 |

[a] Includes placer production.

*Mine production of gold and silver in South Dakota, 1876–1916.*[a]

| Period. | Gold. | Silver. | | Total value (commercial). |
|---|---|---|---|---|
| | | Quantity. | Commercial value. | |
| | | *Fine ounces.* | | |
| 1876–1880 | $11,255,843 | 80,292 | $92,452 | $11,348,295 |
| 1881–1890 | 30,800,000 | 1,472,580 | 1,515,224 | 32,315,224 |
| 1891–1900 | 48,005,555 | 1,729,873 | 1,155,691 | 49,161,246 |
| 1901–1910 | 65,242,196 | 1,790,365 | 1,013,349 | 66,255,545 |
| 1911 | 7,439,874 | 203,755 | 107,990 | 7,547,864 |
| 1912 | 7,891,370 | 206,460 | 126,973 | 8,018,343 |
| 1913 | 7,319,294 | 172,702 | 104,312 | 7,423,606 |
| 1914 | 7,333,508 | 176,642 | 97,683 | 7,431,191 |
| 1915 | 7,406,305 | 199,864 | 101,331 | 7,507,636 |
| 1916 | 7,460,644 | 215,205 | 141,605 | 7,602,249 |
| | 200,154,589 | 6,247,738 | 4,456,610 | 204,611,199 |

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 42, 1914.

*Mine production of gold and silver in South Dakota in 1916.*

| Source. | Number of mines. | Ore. | Gold. | | Silver. | | Total value. |
|---|---|---|---|---|---|---|---|
| | | | Quantity. | Value. | Quantity. | Value. | |
| | | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | | |
| Deep mines: | | | | | | | |
| Siliceous ore | 27 | 1,870,721 | 360,798.54 | $7,458,368 | 214,190 | $140,937 | $7,599,305 |
| Lead ore | 2 | 62 | 7.99 | 165 | 1,009 | 664 | 829 |
| | 29 | 1,870,783 | 360,806.53 | 7,458,533 | 215,199 | 141,601 | 7,600,134 |
| Placer mines | 16 | ..... | 102.12 | 2,111 | 6 | 4 | 2,115 |
| | 45 | 1,870,783 | 360,908.65 | 7,460,644 | 215,205 | 141,605 | 7,602,249 |

[1] Represents 1 pound of quicksilver per 18.28 ounces of gold, or 1 pound of quicksilver per 128 tons of ore.
[2] Potassium and sodium cyanide were used at a ratio of 0.24 pound per ton of ore or tailings treated, and for every pound of cyanide 0.309 ounce of gold was recovered.

## MINING INDUSTRY.

### GENERAL CONDITIONS.

The Homestake mines and mills were operated continuously in 1916, with an increase of ore treated. The company's Ellison shaft was sunk to and below the 2,000-foot level, a station was cut, and crosscutting was started. Sinking will be resumed as soon as the station is clear. Prospecting with diamond drills was done at the Oro Hondo shaft, adjoining the Homestake property. The Golden Reward mill was operated steadily on siliceous ore from its mines and on custom ore; in addition, a considerable quantity of partly oxidized ore continued to be roasted at the Astoria shaft and sent to the mill. The Mogul cyanidation mill was operated steadily on company and custom ore. The capacity of the Trojan mill was increased and the mill was operated steadily on company and custom ore. The Reliance mill was operated up to the end of the year on company and custom ore. The Wasp No. 2 Co. operated its mill and mine through November. The Bismarck mine and mill were idle. The Rattlesnake Jack cyanidation-concentration mill was operated for a period. A small yield of placer gold was made in Custer, Lawrence, and Pennington counties.

### REDUCTION MILLS.

Mineral Resources for 1913, Part I, pages 43–45, contains a complete list of the reduction mills in South Dakota in 1913, with a description of equipment and process. Changes in this list for 1916 have been noted in the text for the several counties, and reference should be made to the 1913 report for the details of equipment.

## REVIEW BY COUNTIES.

### CUSTER COUNTY.

*Mine production of gold, silver, copper, and lead in Custer County, S. Dak., 1904–1916.*

| Year. | Number of mines producing. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 4 | 1,900 | $6,491 | 121 | ..... | ..... | $6,560 |
| 1905 | 5 | 16 | 706 | 3 | 38 | ..... | 714 |
| 1906 | 2 | 16 | 687 | 3 | ..... | ..... | 689 |
| 1907 | 1 | 33 | 332 | 3 | ..... | ..... | 334 |
| 1908 | 2 | 470 | 1,533 | 4 | ..... | ..... | 1,535 |
| 1909 | 1 | 400 | 1,311 | 21 | ..... | ..... | 1,322 |
| 1910 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1911 | 5 | ..... | 309 | 4 | ..... | ..... | 311 |
| 1912 | 5 | 75 | 1,187 | 3 | ..... | ..... | 1,189 |
| 1913 | 5 | 5 | 194 | 1 | 1,503 | ..... | 428 |
| 1914 | 2 | 17 | 206 | 5 | ..... | ..... | 209 |
| 1915 | 3 | 5 | 409 | 65 | ..... | 3,107 | 588 |
| 1916 | 3 | ..... | 123 | ..... | ..... | ..... | 123 |
| Decrease | ..... | 5 | 286 | 65 | ..... | 3,107 | 485 |

[a] Includes both placer and deep mines.

No output was made from the deep mines of Custer County. A small yield of placer gold was recovered by sluicing near Custer.

The Cuyahoga Mining Co., in the Keystone district, but in Custer County, shipped several cars of pyrite ore carrying a small quantity of copper, which was utilized for its sulphur content only.

## LAWRENCE COUNTY.[1]

*Mine production of gold, silver, copper, and lead in Lawrence County, S. Dak., 1904–1916.*

| Year. | Number of mines producing. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 44 | 1,801,524 | $7,346,986 | 161,216 | ..... | ..... | $7,439,282 |
| 1905 | 19 | 1,826,177 | 6,955,690 | 182,597 | ..... | ..... | 7,065,979 |
| 1906 | 27 | 1,771,377 | 6,816,196 | 150,537 | ..... | 22,719 | 6,918,351 |
| 1907 | 22 | 1,470,154 | 4,134,667 | 93,830 | ..... | ..... | 4,196,595 |
| 1908 | 17 | 1,927,844 | 7,650,523 | 248,686 | ..... | 23,046 | 7,783,295 |
| 1909 | 17 | 1,699,260 | 6,561,628 | 191,044 | 3,977 | 1,512 | 6,661,553 |
| 1910 | 19 | 1,522,986 | 5,380,795 | 118,716 | ..... | 14,136 | 5,445,523 |
| 1911 | 16 | 1,940,719 | 7,408,356 | 203,350 | ..... | 64,311 | 7,519,025 |
| 1912 | 19 | 1,901,310 | 7,875,401 | 206,356 | ..... | 22,845 | 8,003,338 |
| 1913 | 20 | 1,899,162 | 7,317,320 | 172,688 | 290 | 10,205 | 7,422,117 |
| 1914 | 21 | 2,019,016 | 7,331,638 | 176,585 | ..... | 2,766 | 7,429,397 |
| 1915 | 25 | 1,889,970 | 7,405,552 | 199,797 | ..... | ..... | 7,506,849 |
| 1916 | 29 | 1,870,572 | 7,455,136 | 215,127 | ..... | 35,406 | 7,599,127 |
| Increase or decrease. | + 4 | − 19,398 | + 49,578 | + 15,330 | ..... | + 35,406 | + 92,278 |

[a] Includes both placer and deep mines.

Richard Blackstone,[2] superintendent of the Homestake Mining Co., has recently written a history of the Homestake mine, covering the present belt of consolidated properties, the Homestake, the Highland, the Golden Terra, the Deadwood, and the Father De Smet mines. These locations join each other and extend northwesterly in the order named. The Homestake mine and the Highland mine were separately incorporated and organized, but were operated by the same superintendent; the Golden Terra, Deadwood, and Father De Smet each had its own superintendent and manager. Blackstone gives the total production and dividends paid by the companies now consolidated in the Homestake Mining Co. from 1875 to 1916 as follows:

*Production of Homestake mine, 1875–1916.*

| | Ore milled. | Value of product. | Value per ton. | Dividends. |
|---|---|---|---|---|
| | *Short tons.* | | | |
| Homestake Mining Co., to May 31, 1900 | ..... | $31,204,685.28 | ..... | $8,668,750.00 |
| Highland Mining Co., to May 31, 1900 | ..... | 13,359,398.95 | ..... | 3,834,717.69 |
| Caledonia Gold Mining Co., to May 31, 1900 | ..... | 2,341,130.92 | ..... | 192,000.00 |
| Deadwood-Terra Mining Co., to May 31, 1900 | ..... | 9,001,002.61 | ..... | 1,350,000.00 |
| Deadwood Mining Co., to May 31, 1900 | ..... | 834,192.28 | ..... | 275,000.00 |
| Father de Smet Mining Co., to May 31, 1900 | ..... | 3,421,199.01 | ..... | 1,125,000.00 |
| Gopher Mining Co., to May 31, 1900 | ..... | 71,140.41 | ..... | ..... |
| Clara Consolidated Mining Co., to May 31, 1900 | ..... | 13,590.56 | ..... | ..... |
| Total to June 1, 1900 | ..... | 60,246,340.02 | ..... | 15,445,467.69 |

[1] For information on the geology of this county see Irving, J. D., Ore deposits of the northern Black Hills: U. S. Geol. Survey Bull. 225, pp. 123–140, 1904. Irving, J. D., and Emmons, S. F., Economic resources of northern Black Hills: U. S. Geol. Survey Prof. Paper 26, pp. 53–212, 1904.

[2] Blackstone, Richard. A history of the Homestake mine, South Dakota: Min. and Eng. World, July 15, 1916, pp. 99–102; South Dakota School of Mines Pahasapa Quart., June, 1916, pp. 16–30.

*Production of Homestake mine, 1875–1916*—Continued.

| | Ore milled. | Value of product. | Value per ton. | Dividends. |
|---|---|---|---|---|
| HOMESTAKE MINING CO. | *Short tons.* | | | |
| June 1, 1900, to June 1, 1901 | | $3,639,232.03 | | $1,260,000.00 |
| June 1, 1901, to June 1, 1902 | | 4,303,977.57 | | 1,260,000.00 |
| June 1, 1902, to June 1, 1903 | | 4,526,942.04 | | 819,000.00 |
| June 1, 1903, to June 1, 1904 | | 4,800,558.48 | | 655,200.00 |
| June 1, 1904, to June 1, 1905 | | 5,221,089.30 | | 819,000.00 |
| June 1, 1905, to June 1, 1906 | | 5,100,445.49 | | 1,310,400.00 |
| June 1, 1906, to June 1, 1907 | | 4,541,096.07 | | 1,201,200.00 |
| June 1, 1907, to June 1, 1908 | | 4,717,746.20 | | 546,000.00 |
| June 1, 1908, to June 1, 1909 | | 5,725,046.67 | | 1,365,000.00 |
| June 1, 1909, to June 1, 1910 | 1,237,381 | 4,498,751.11 | $3.6357 | 982,800.00 |
| June 1, 1910, to June 1, 1911 | 1,468,203 | 5,251,453.75 | 3.5766 | 1,310,400.00 |
| June 1, 1911, to Dec. 31, 1911 | 888,057 | 3,661,151.60 | 4.1205 | 764,400.00 |
| Calendar year 1912 | 1,528,923 | 6,600,953.12 | 4.3174 | 1,310,400.00 |
| Calendar year 1913 | 1,540,961 | 6,186,651.78 | 4.0148 | 2,146,224.00 |
| Calendar year 1914 | 1,587,774 | 6,160,160.59 | 3.8798 | 2,210,208.00 |
| Calendar year 1915 | 1,573,822 | 6,428,736.56 | 4.0848 | 2,210,208.00 |
| Calendar year 1916 | 1,600,220 | 6,531,003.34 | 4.0813 | 2,210,208.00 |
| Grand total | | 148,141,385.72 | | 37,826,116.29 |

For the calendar year 1916 the Homestake Co.'s public report says:

The year 1916, just closed, has been another very satisfactory one, both as to output and operation, at the Homestake mine. The central steam-boiler plant has been tested and found ample in capacity for the work intended. The steam turbo-generators are in full operation and have been supplying all shortage of electric power due to shortage of water at the hydroelectric stations. The rebuilding of the mechanical parts of stamp mills and amalgamating tables has all been completed and mills are in excellent shape for continuous work. A five-stamp crushing and concentrating mill was built early in the year and has been in continuous operation on tungsten ores. It is equipped with one Wilfley table and two Deister slime tables and is doing very satisfactory work. The source for tungsten ore is in the quartzite or Potsdam measures occurring to the westerly or footwall side of the Homestake mine and accompanies the siliceous gold ores mixed in the same bed. The supply is promising for some months to come. Two tube mills additional have been installed in the regrind and a rearrangement of mills in more convenient shape has been effected. The last section of 4 miles of the Little Rapid Creek ditch has been replaced with vitrified pipe. Development work in the mine was continued to same extent as in the previous year. The Ellison shaft was sunk to and below the 2,000-foot level, a station cut, and crosscutting is in progress. Sinking wil lbe resumed as soon as the station is clear. During the year 2,399 feet of raises and 21,982 feet of drifts have been driven in development work. The mine, hoists, and reduction works are all in first-class shape and call for no outlay other than ordinary repair. The ore reserves are large and seemingly undiminished from last year's report.

In addition to gold and silver $229,915.89 was obtained from the sale of tungsten ores by the Homestake Co. An interesting source of revenue by this company is from silver plating amalgamation plates—$14,962.59 was recovered, as against an expenditure of $41,-815.73 for silver plating in 1916. Much of the silver plating is recovered when the amalgamation plates are scraped and it causes a higher recovery in silver than the ore would warrant. What quantity of silver thus finds its way back to market in the amalgamation bullion no one can say.

Diamond drilling was done from the Oro Hondo shaft, which is 2,000 feet in depth.

In the Bald Mountain area and the Portland district the Golden Reward group of mines was operated steadily, and both siliceous

oxidized ore and roasted[1] unoxidized ore were sent to the 150-ton cyanidation plant of the Golden Reward below Deadwood. This plant was operated steadily on company and custom ore. The Mogul cyanidation mill at Terry was operated regularly, chiefly on custom ore, but also on ore from its own mines.

The Trojan mill was operated with increased capacity, chiefly on ores from its own property, but some custom ores were also handled. Some ore from the Golden Reward mine and from the Trojan mine, but a smaller quantity than in previous years, was shipped direct to smelters. The New Reliance mine and mill were operated steadily, but were closed at the end of 1916. Other large producers of this district in 1916 were the Apex group, American Express, Baltimore, Lackawanna, and Monday claims of the Ofer Co., formerly the Imperial Co. The Elk Mountain or Maleta mine was also operated during the year, the ore being treated at the Deadwood-Standard mill.

In the Bear Butte (or Galena) district shipments of lead ore were made from the General Merritt No. 2 and General Merritt No. 1, and gold-silver ores were shipped from the Sitting Bull and War Eagle claims. The 50-ton cyanidation-concentration mill on the Rattlesnake Jack mine was operated for a period.

In the Custer Peak district considerable development work was done on the Custer Peak mine.

In the Maitland district shipments were made from the Republic mine to custom mills.

In the Yellow Creek area the Wasp No. 2 mine and mill were operated nearly all the year. This mine is opened both by underground workings and by surface open cuts, a steam shovel being used in the surface workings. The mill is a 500-ton dry-crushing cyanidation plant. The Bismarck mine and mill were idle.

In the Rawlings district, near Tinton, a small yield of placer gold was made from several placers located chiefly in Bear Gulch and Potato Creek.

## PENNINGTON COUNTY.

*Mine production of gold, silver, copper, and lead in Pennington County, S. Dak., 1904–1916.*

| Year. | Number of mines producing. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1904 | 16 | 1,511 | $10,500 | 274 | ..... | ..... | $10,657 |
| 1905 | 8 | 11,218 | 33,096 | 149 | ..... | ..... | 33,186 |
| 1906 | 6 | 9,281 | 24,586 | 335 | ..... | ..... | 24,810 |
| 1907 | 7 | 969 | 3,190 | 62 | ..... | ..... | 3,231 |
| 1908 | 8 | 1,235 | 5,320 | 72 | ..... | ..... | 5,358 |
| 1909 | 13 | 4,481 | 14,897 | 3,208 | 114,408 | ..... | 31,438 |
| 1910 | 7 | 943 | 21,462 | 84 | ..... | ..... | 21,508 |
| 1911 | 16 | 5,408 | 31,209 | 401 | ..... | ..... | 31,422 |
| 1912 | 16 | 341 | 14,782 | 101 | ..... | ..... | 14,844 |
| 1913 | 5 | ..... | 1,780 | 13 | ..... | ..... | 1,788 |
| 1914 | 8 | 229 | 1,664 | 52 | ..... | 1,131 | 1,737 |
| 1915 | 10 | ..... | 344 | 2 | ..... | ..... | 345 |
| 1916 | 6 | 211 | 5,391 | 78 | ..... | ..... | 5,442 |
| Increase or decrease... | −4 | +211 | +5,047 | +76 | ..... | ..... | +5,097 |

[a] Includes both deep and placer mines.

[1] For description of roaster see Willard, C. G., The Golden Reward roaster: South Dakota School of Mines Pahasapa Quart., June, 1916, pp. 40–45.

A small shipment of gold-silver ore was made from the Antlers mine, near Hill City. At the Limelight mine, 17 miles west of Hill City, development work was carried on and a small test run was made in the 20-stamp amalgamation mill on the property.

In the Hornblende district, near Rochford, assessment work was done on several properties.

In the Keystone district, a test run was made on gold-silver ore from the Lisbon group, in the 10-stamp mill on the property. Later concentrating tables were added to the equipment of the mill. Several cars of gold ore of commercial grade were shipped from the Columbia mine.

Placer mines on Battle, Rapid, and Spring creeks yielded a small quantity of gold.

# GOLD, SILVER, AND COPPER IN WYOMING.

(MINES REPORT.)

By CHARLES W. HENDERSON.

## PRODUCTION.

The total value of the production of gold, silver, and copper in the State of Wyoming in 1916 was $666,414, as compared with $93,286 in 1915. This is the largest yield in value since 1900, and with the exception of 1900 the largest yearly output since the beginning of mining in Wyoming in 1842. The copper production alone was valued at $642,213. There were 28 producing mines, of which 24 were deep and 4 placer, an increase of 16 deep and 1 placer as compared with 1915. The quantity of ore sold or treated was 8,876 tons, as compared with 4,216 tons in 1915. The deep mines yielded $20,217 in gold, 5,523 ounces of silver, and 2,610,622 pounds of copper. The placer gold production amounted to $349 in 1916, as against $704 in 1915.

*Mine production of gold, silver, and copper in Wyoming, 1915 and 1916.*

| Year. | Ore. | Gold.[a] | | Silver.[a] | | Copper. | | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | | *Pounds.* | | |
| 1915 | 4,216 | 705.89 | $14,592 | 840 | $426 | 447,246 | $78,268 | $93,286 |
| 1916 | 8,876 | 994.88 | 20,566 | 5,524 | 3,635 | 2,610,622 | 642,213 | 666,414 |
| Increase | 4,660 | 288.99 | 5,974 | 4,684 | 3,209 | 2,163,376 | 563,945 | 573,128 |

[a] Includes placer production.

*Mine production of gold, silver, and copper in Wyoming, 1842–1916.*[a]

| Period | Gold. | Silver. | | Copper. | | Total value. |
|---|---|---|---|---|---|---|
| | Value. | Quantity. | Commercial value. | Quantity. | Value. | |
| | | *Fine ounces.* | | *Pounds.* | | |
| 1842–1867 | (b) | | | | | |
| 1867–1870 | $396,100 | 3,170 | $4,098 | | | $400,198 |
| 1871–1880 | 400,000 | 3,240 | 4,115 | | | 404,115 |
| 1881–1890 | 67,500 | 2,940 | 3,126 | 1,395,287 | $230,521 | 301,147 |
| 1891–1900 | 131,700 | 1,400 | 943 | 7,541,647 | 1,257,649 | 1,390,292 |
| 1901–1910 | 130,259 | 45,983 | 26,896 | 16,906,466 | 2,579,095 | 2,736,250 |
| 1911 | 19,200 | 725 | 384 | 130,499 | 16,312 | 35,896 |
| 1912 | 22,235 | 265 | 163 | 25,080 | 4,138 | 26,536 |
| 1913 | 24,184 | 957 | 578 | 385,239 | 59,712 | 84,474 |
| 1914 | 5,006 | 116 | 64 | 17,421 | 2,317 | 7,387 |
| 1915 | 14,592 | 840 | 426 | 447,246 | 78,268 | 93,286 |
| 1916 | 20,566 | 5,524 | 3,635 | 2,610,622 | 642,213 | 666,414 |
| | 1,231,342 | 65,160 | 44,428 | 29,459,507 | 4,870,225 | 6,145,995 |

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 926, 1913.

[b] Small; unknown.

*Mine production of gold and silver in Wyoming, 1915 and 1916.*

| Source. | Number of mines. | Ore. | Gold. | | Silver. | | Total value. |
|---|---|---|---|---|---|---|---|
| | | | Quantity. | Value. | Quantity. | Value. | |
| Deep mines, 1916: | | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | | |
| Siliceous ore | 6 | 2,813 | 923.55 | $19,091 | 289 | $190 | $19,281 |
| Copper ore | 18 | 6,063 | 54.45 | 1,126 | 5,234 | 3,444 | 4,570 |
| Total deep mines: | | | | | | | |
| 1915 | 8 | 4,216 | 671.83 | 13,888 | 838 | 425 | 14,313 |
| 1916 | 24 | 8,876 | 978.00 | 20,217 | 5,523 | 3,634 | 23,851 |
| Increase | 16 | 4,660 | 306.17 | 6,329 | 4,685 | 3,209 | 9,538 |
| Placer mines, 1915 | 3 | ..... | 34.06 | 704 | 2 | 1 | 705 |
| Placer mines, 1916 | 4 | ..... | 16.88 | 349 | 1 | 1 | 350 |
| Increase or decrease | +1 | ..... | −17.18 | −355 | −1 | ..... | −355 |
| Total deep and placer mines, 1916 | 28 | 8,876 | 994.88 | 20,566 | 5,524 | 3,635 | 24,201 |

## MINING INDUSTRY.

The Hartville district, Platte County, remained the principal producing district in Wyoming in 1916. Shipments of high-grade copper ore from this district increased heavily. The Encampment district, Carbon County, long idle, became the second district in importance in 1916, owing to shipments of comparatively high-grade copper ore. Operations were continued at the amalgamation mill on the Penn and King mines, in the Seminole district, Carbon County. Several cars of ore and concentrates were shipped from the Rambler copper-platinum-palladium property, at Holmes, Albany County. Shipments of copper ore were made from the Esterbrook district, Converse County; Manville district, Goshen County; Silver Crown (Hecla) district, Laramie County; and the Cokeville district, Lincoln County. The Atlantic City (South Pass) district, Fremont County, which had been the principal producing district for several years prior to 1915, made a small yield of gold from the test run of the Armstead mill on ore from the Bobtail mine and from clean-up operations at the Federal mill from ore from the Ben Hur-Lucky Strike (formerly Carissa) mines. A small quantity of gold was also recovered from placer mines in the Atlantic City district.

## REVIEW BY COUNTIES.[1]

### ALBANY COUNTY.[2]

From the Rambler mine, near Holmes, which is opened by a 170-foot vertical shaft and 5,000 feet of drifts and crosscuts and equipped with a 50-ton concentration mill, several cars of ore and concentrates carrying platinum, palladium, copper, silver, and gold were shipped

[1] In this review the footnote references indicate publications containing information on the geology of the respective regions.

[2] Emmons, S. F., Platinum in copper ores in Wyoming: U. S. Geol. Survey Bull. 213, pp. 94–97, 1903. Kemp, J. F., Platinum in the Rambler mine, Wyo.: U. S. Geol. Survey Mineral Resources, 1902, pp. 244–250, 1904. Platinum in Wyoming: Eng. and Min. Jour., Mar. 4, 1911, p. 460. Concentration of platiniferous copper ore at the Rambler mine, Wyo.: Met. and Chem. Eng., February, 1911, pp. 75–78.

to eastern refineries. The mill, as now equipped, will not be operated in the future. A clean-up of an old mill in the Keystone district (south of Holmes) yielded some gold bullion. Development work was done on several other properties in the Holmes district.

In the Centennial district, a small quantity of ore from the Fram mine was treated in the 3-stamp amalgamation-concentration mill on the property. Assessment work was done on several other properties.

*Mine production of gold, silver, and copper in Albany County,[a] Wyo., 1868–1916.*

| Year. | Ore. | Gold. | | Silver. | Copper. |
|---|---|---|---|---|---|
| | | Placer. | Deep mines. | | |
| | *Short tons.* | | | *Fine ounces.* | *Pounds.* |
| 1868–1893 | ..... | [b] $40,000 | [b] $189,000 | ..... | ..... |
| 1901–1912 | ..... | [c] 945 | ..... | ..... | ..... |
| 1901–1903 | ..... | ..... | ..... | ..... | [c] 900,532 |
| 1907 | ..... | ..... | ..... | ..... | [c d] 24,350 |
| 1909–1912 | [c e] 3,071 | ..... | [c] 2,108 | [b] 3,213 | [c] 700,567 |
| 1913 | ..... | ..... | ..... | ..... | ..... |
| 1914 | ..... | ..... | ..... | ..... | ..... |
| 1915 | ..... | ..... | ..... | ..... | ..... |
| 1916 | ..... | ..... | ..... | ..... | ..... |

[a] Chiefly Douglas Creek district.
[b] Knight, W. C., The mining districts of Albany County: Wyoming Univ. Agr. Coll. Dept. Bull. 14, p. 128, October, 1893. (Probably too high, considering total production of Wyoming for these years.)
[c] Mineral Resources records.
[d] Beeler, H. C., Mineral resources of Wyoming, p. 27, State Board of Immigration, Cheyenne, Wyo., 1907, gives 828,700 pounds for production of the Rambler mine to date (1907).
[e] For one year tonnage of concentrates used instead of crude ore, giving therefor tonnage and contents of materials smelted. The concentrates were little better than the original crude ore.
[f] Rambler mine only.

## BIG HORN COUNTY.[1]

No work was done in this county in 1916.

## CARBON COUNTY.[2]

A shipment of copper ore was made from the Elkhorn mine in the Elk Mountain district.

In the Seminole distict, 38 miles northeast of Rawlins, the Penn, Seminole, and King mines, opened by a 350-foot adit and 950 feet of drifts and equipped with a 20-stamp amalgamation mill, was operated until April, 1916. Development work by shaft has since been commenced.

A quantity of copper ore was shipped from the Encampment district. Considerable development and assessment work was done in this district.

[1] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (No. 141) and Cloud Peak-Fort McKinney folio (No. 142), 1906; Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper 51, 1906. Fisher, C. A., Geology and water resources of Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, 1906.

[2] Spencer, A. C., Mineral resources of the Encampment copper region, Wyo.: U. S. Geol. Survey Bull. 213, pp. 158–162, 1903. Spencer, A. C., Copper deposits of the Encampment district, Wyo.: U. S. Geol. Survey Prof. Paper 25, 107 pp., 1904. See also Spencer, A. C., Reconnaissance examination of the copper deposits at Pearl, Colo.: U. S. Geol. Survey Bull. 213, pp. 163–169, 1903.

*Mine production of gold, silver, and copper in Carbon County,[a] Wyo., 1898–1916.*

| Year. | Ore. | Gold. | Silver. | | Copper. | | Total value. |
|---|---|---|---|---|---|---|---|
| | | | Quantity. | Commercial value. | Quantity. | Value. | |
| | *Short tons.* | | *Fine ounces.* | | *Pounds.* | | |
| 1898 | [b] 2,484 | [b] $497 | [b] 314 | $185 | [c] 233,044 | $28,897 | $29,579 |
| 1899 | [b] 33,095 | [b] 6,619 | [b] 4,183 | 2,510 | [c] 3,104,827 | 530,925 | 540,054 |
| 1900 | [b] 44,808 | [b] 8,962 | [b] 5,663 | 3,511 | [c] 4,203,776 | 697,827 | 710,300 |
| 1901 | [b] 28,766 | [b] 5,753 | [b] 3,636 | 2,182 | [cd] 2,698,712 | 450,685 | 458,620 |
| 1902 | [b] 2,536 | [b] 507 | [b] 321 | 170 | [cd] 237,892 | 29,023 | 29,700 |
| 1903 | [b] 8,250 | [b] 1,650 | [b] 1,043 | 563 | [c] 773,993 | 106,037 | 108,250 |
| 1904 | 41,370 | 6,593 | 4,483 | 2,600 | [c] 3,527,008 | 451,457 | 460,650 |
| 1905 | 28,039 | 4,678 | 3,549 | 2,165 | [c] 2,385,628 | 372,158 | 379,001 |
| 1906 | 60 | ..... | ..... | ..... | [c] 24,000 | 4,632 | 4,632 |
| 1907 | 25,950 | 4,802 | 2,982 | 1,968 | [c] 2,206,065 | 441,213 | 447,983 |
| 1908 | 18,851 | 6,181 | 3,123 | 1,655 | [c] 2,367,666 | 312,532 | 320,368 |
| 1909 | 150 | ..... | ..... | ..... | [c] 33,431 | 4,346 | 4,346 |
| 1910 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1911 | 20 | ..... | 21 | 11 | [c] 4,738 | 592 | 603 |
| 1912 | ..... | [f] 27 | ..... | ..... | ..... | ..... | 27 |
| 1913 | ..... | [f] 424 | 8 | 5 | ..... | ..... | 429 |
| 1914 | [g] 47 | 141 | 26 | 14 | 4,439 | 590 | 745 |
| 1915 | [h] 2,976 | [h] 12,810 | [h] 296 | 150 | [h] 13,074 | 2,288 | 15,248 |
| 1916 | [i] 3,404 | [i] 13,342 | [i] 617 | 406 | [i] 193,943 | 47,710 | 61,458 |
| | 240,806 | 72,986 | 30,265 | 18,095 | 22,012,236 | 3,480,912 | 3,571,903 |

[a] From 1898 to 1909 this is almost entirely the production of the Encampment district, there being only small yields from other districts of Carbon County. Average per ton of ore 1898 to 1909: Gold, $0.199; silver, 0.129 ounce; copper, 93 pounds, or 4.62 per cent.
[b] Estimated by Charles W. Henderson.
[c] Smelter figures.
[d] The Encampment production for 1901–2 is the total Wyoming copper production less the Douglas Creek, Albany County, copper production. The Douglas Creek figures are available only for the two years combined. This combined production has been subtracted from the total Wyoming production for 1902, none being subtracted from the 1901 figures. In either event the total pounds of copper produced in each camp would be unchanged.
[e] Mine figures.
[f] Placer output.
[g] Saratoga and Seminole districts.
[h] Seminole and Elk Mountain districts.
[i] Elk Mountain, Seminole, and Encampment districts.

## CONVERSE COUNTY.

Several cars of low-grade copper ore from surface workings were shipped from the Mewis property in the Cold Springs district. Development work was done at the Saul's Camp mine, 26 miles south of Douglas. This property is opened by a 100-foot shaft.

## CROOK COUNTY.

No placer gold was recovered in the Hurricane district, northwest of Tinton, S. Dak.

Assessment work was done on the properties in the Bear Lodge district,[1] near Sundance.

## FREMONT COUNTY.

*Atlantic City (South Pass) district.*[2]—A test run on ore from the Bobtail mine at the Armstead mill, which commenced in December, 1915, resulted in a "clean-up" of gold-silver bullion early in January, 1916. No more work was done after this. A "clean-up" of

[1] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Sundance folio (No. 127), 1905.
[2] Trumbull, L. W., Atlantic City gold mining district, Fremont County, Wyo.: Wyoming State Geologist Bull. 7, ser. B, 1914.

bullion and old concentrates and tailings from the Federal mill from ore which originally came from the Ben Hur-Lucky Strike mines was marketed in 1916. The mine and mill are being kept in repair. Several small lots of placer gold from the Atlantic City district were marketed in 1916. Very little development work was done in this district in 1916.

*Copper Mountain district.*—The Williams-Luman property was reopened in 1916 and shipments were made in 1917. Development work was commenced on several other properties in this district.

*Gold placers on Wind and Big Horn rivers.*[1]—No yield was made from these deposits.

### GOSHEN COUNTY.

A small shipment of copper ore was made from the Silver Glance mine on Muskrat Creek.

### JOHNSON COUNTY.[2]

Assessment work was done at the Big Goose mines. An adit is being run to connect with the bottom of the shaft. It is estimated that it will take three years to complete the work.

Assessment work was done in the Bull Camp district.

No work was done in the Kelly Creek district nor in the Onion Creek placer district.

### LARAMIE COUNTY.

Several cars of copper-gold-silver ore were shipped from the Comstock and Dan Jo Claims, in the Hecla, or Silver Crown district.

### LINCOLN COUNTY.[3]

Several cars of silver-copper ore were shipped from the Cokeville district.

Assessment work was done on the silver-copper prospects—Golden Eagle and Copper King claims—in the Rock Creek district, west of Kemmerer.

### NATRONA COUNTY.

In the Casper Mountain district, 10 miles south of Casper, assessment work was done on the Nettie M. mine, from which in 1914 a car of copper ore had been shipped from the surface.

### PARK COUNTY.

Only a small amount of assessment work was done in the Sunlight and Kirwin district.[4]

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[1] Schrader, F. C., Gold placers on Wind and Bighorn rivers, Wyo.: U. S. Geol. Survey Bull. 580, pp. 127–145, 1915.

[2] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (No. 141) and Cloud Peak-Fort McKinney folio (No. 142), 1906; also Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper 51, 1906.

[3] Schultz, A. R., Gold developments in central Uinta County, Wyo., and at other points on Snake River: U. S. Geol. Survey Bull. 315, pp. 71–88, 1907.

[4] Hewett, D. F., The ore deposits of Kirwin, Wyo.: U. S. Geol. Survey Bull. 540, pp. 121–132, 1914.

## PLATTE COUNTY.[1]

An increased quantity of copper-silver ore was shipped from the Hartville district[2] in 1916, chiefly from the Sunrise mine, near Sunrise. Other producing mines were the Copper Bottom-Green Hope, Empire group, Green Mountain Boy, Indian Mountain, Shorty Miller-Lucky Strike group, and Wild Cat.

*Mine production of silver and copper in the Hartville district, Platte County, Wyo., 1882–1916.*[a]

| Year. | Ore. | Silver. | | Copper. | | Total value. |
|---|---|---|---|---|---|---|
| | | Quantity. | Commercial value. | Quantity. | Value. | |
| | *Short tons.* | *Fine ounces.* | | *Pounds.* | | |
| 1882 | ..... | [b] 140 | $160 | 100.000 | $19,100 | $19,260 |
| 1883 | ..... | [b] 1,340 | 1,487 | 962,468 | 158,807 | 160,294 |
| 1888 | ..... | [b] 320 | 301 | 232,819 | 39,114 | 39,415 |
| 1889 | ..... | [b] 140 | 132 | 100,000 | 13,500 | 13,632 |
| 1882–1889 | [c] 4,651 | [b] 1,940 | 2,080 | 1,395,287 | 230,521 | 232,601 |
| 1907–1909, 1911–12 | [d] 539 | [e] 342 | 188 | 172,875 | 23,127 | 23,315 |
| 1913 | [d] 964 | 831 | 502 | 385,239 | 59,712 | 60,214 |
| 1914 | 30 | 45 | 25 | 10,012 | 1,336 | 1,361 |
| 1915 | 914 | 55 | 28 | 415,394 | 72,694 | 72,722 |
| 1916 | 4,758 | 3,122 | 2,054 | 2,381,301 | 585,800 | 587,854 |
| | 11,856 | 6,335 | 4,877 | 4,760,138 | 973,190 | 978,067 |

[a] For basis of figures, see Kirchoff, C., jr., The copper industry of the United States: U. S. Geol. Survey Mineral Resources for 1881–82, pp. 216, 229, 1883; idem for 1883–84, p. 329, 1885. Knight, W. C., The Hartville district: Wyoming Univ. Agr. Coll. Dept. Bull. 14, pp. 135–136, October, 1893.

[b] Estimated by Charles W. Henderson on Mr. Kirchhoff's statement that ore contained ½ to ¾ ounce of silver for every per cent of copper.

[c] Estimated on basis of 15 per cent copper per ton (Kirchhoff).

[d] Mineral Resources records collected from the mines.

[e] Mineral Resources records, 1911–12. Estimated on 1911–12 record for 1907, 1908, 1909.

## SHERIDAN COUNTY.

No work was done on the prospects in the Black Mountain, Wolf Creek, and Tongue River districts.

## UINTA COUNTY.[3]

In 1915 the greater part of the area of this county was separated into the new county of Lincoln, only the more populous southern area remaining in Uinta County.

No production was reported in 1915 from Uinta County, nor are any prospects known.

[1] The northwestern part of Laramie County prior to 1913.

[2] Smith, W. S. T., U. S. Geol. Survey Geol. Atlas, Hartville folio (No. 91), 1903. Ball, S. H., Copper deposits of the Hartville uplift, Wyoming: U. S. Geol. Survey Bull. 315, pp. 93–107, 1907.

[3] Schultz, A. R., Gold developments in central Uinta County, Wyo., and at other points on Snake River: U. S. Geol. Survey Bull. 315, pp. 71–88, 1907.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN ARIZONA.

(MINES REPORT.)

By V. C. Heikes.

## PRODUCTION.

### GENERAL STATEMENT.

In 1916 the mines of Arizona produced gold, silver, copper, lead, and recoverable zinc valued at $190,806,170, and contained in bullion, ore of shipping grade, and concentrates. The value of the output, when compared with that of 1915, increased $99,999,821, or 110 per cent. There were 504 producers from deep mines and 23 producers from placers, as against 468 deep-mine and 49 placer producers in 1915. The increase in the value of the metal output in 1916 was principally in copper; there was also an increase in silver, lead, and zinc, but a small decrease in gold.

*Mine production of gold, silver, copper, lead, and recoverable zinc in Arizona in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.a | Silver.a | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 517 | 9,612,559 | $4,166,025 | 5,649,020 | 459,972,295 | 21,738,969 | 18,220,863 | $90,806,349 |
| 1916 | 527 | 17,033,810 | 3,985,559 | 7,212,039 | 721,833,169 | 27,062,087 | 19,677,949 | 190,806,170 |
| Increase or decrease, 1916 | ..... | +7,421,251 | −180,466 | +1,563,019 | +261,860,874 | +5,323,118 | +1,457,086 | +99,999,821 |

a Includes placer production.

### ORE.

Arizona is credited with a total production of 17,033,810 tons of ore in 1916, which, notwithstanding the strike in the Clifton-Morenci region the first part of the year, was 7,421,251 tons more than the output in 1915. The total average value per ton increased from $9.44 in 1915 to $11.20 in 1916, but the gold and silver value per ton decreased from 73 cents to 51 cents. The dry or siliceous ores de-

creased from 340,798 tons in 1915 to 336,304 tons in 1916. This classification includes 164,918 tons of siliceous gold ore, averaging $7.97 in gold and 0.88 ounce of silver per ton. These ores were principally from Mohave, Maricopa, Yavapai, and Pinal counties. Gold and silver ores, dry or siliceous in character, produced in various districts, aggregated 1,470 tons and averaged per ton $13.98 in gold, 21.90 ounces of silver, and 7.83 pounds of copper. The siliceous silver ores produced in 1916 aggregated 169,916 tons, averaging per ton $1.08 in gold, 4.82 ounces of silver, 0.80 pound of copper, and 0.178 pound of lead. These ores were produced chiefly in the Turquoise and Tombstone districts of Cochise County.

The copper ore mined by 272 producers amounted to 16,491,971 tons, against 9,134,425 tons mined by 246 producers in 1915. The copper ore mined in 1916 included the low-grade disseminated copper ores at Ray and in the Globe district, where 10,490,707 tons were treated at concentration mills. Similar ores amounting to 1,664,243 tons were mined and milled for copper in Greenlee County, which embraces the Clifton and Morenci camps. Thus the total output of disseminated ores amounted to 12,154,950 tons, yielding 299,704,303 pounds of copper, or more than 41 per cent of the total output of copper. There were mined and smelted directly (without previous concentration) 3,701,716 tons of crude copper ores, averaging 53 cents in gold and 1.22 ounces of silver per ton, and 5.19 per cent of copper, with a total value of $26.86 a ton, against 2,558,301 tons in 1915, with an average value of $19.55 a ton. Of the copper ores smelted directly, 2,686,342 tons were sulphides averaging 63 cents in gold and 1.40 ounces of silver per ton, and 5.50 per cent of copper, and having an average value of $28.63 a ton. The oxidized copper ore smelted, 1,015,374 tons in quantity, contained 28 cents in gold and 0.72 ounce of silver per ton, and 4.36 per cent of copper, and was valued at $22.18 a ton. There was an increase in the quantity of lead ores smelted, which amounted to 46,930 tons in 1916, against 34,938 tons in 1915. The larger part, or 42,904 tons, was oxidized, and 4,026 tons were sulphide ores. The oxidized ores contained $2.14 in gold and 10.37 ounces of silver per ton, and 0.86 per cent copper and 20.08 per cent of lead, and had a total average value of $40.92 a ton. The quantity of zinc ores mined increased from 40,458 tons in 1915 to 52,652 tons in 1916. Of this ore, 2,929 tons, mainly sulphide ores, were shipped crude to smelters. The remainder of the zinc ore, 49,723 tons, was concentrated and yielded 13,758 tons of concentrate. The lead-zinc ores amounted to 55,956 tons, of which 372 tons, mostly oxidized crude ore, was shipped to smelters, and 51,584 tons of ore and 4,000 tons of old tailing were concentrated and yielded 12,328 tons of zinc concentrate, 8,567 tons of lead concentrate, and 23 tons of lead-zinc concentrate. The copper-lead ore, most of which was shipped to the smelter, amounted to 3,900 tons in quantity. The larger part was oxidized, there being only 190 tons classified as sulphide. The oxidized ores contained 12 cents in gold and 7.90 ounces of silver per ton, and 4.26 per cent of copper and 12.07 per cent of lead, and had an average value of $42.96 a ton. There were 116 tons of copper-lead ore treated at concentrating mills, which yielded 33 tons of copper-lead concentrate. There were also 11,280 tons of copper-zinc ore and 8,000 tons of old tailings concentrated, which produced 2,666 tons of copper concentrate and averaged 9.57 per cent

of copper and 2,445 tons of zinc concentrate, which averaged 25.15 per cent of zinc.

*Ore and metals produced in Arizona in 1916.*

| Source of production. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Placers | 23 | ..... | 690.84 | 171 | ..... | ..... | ..... |
| Dry or siliceous ore | 138 | 336,304 | 73,414.67 | 997,372 | 162,897 | 114,489 | ..... |
| Copper ore | 272 | 16,491,971 | 105,467.71 | 5,347,893 | 719,702,789 | 27,500 | ..... |
| Lead ore | 97 | 73,747 | 5,793.20 | 539,108 | 786,960 | 20,087,853 | ..... |
| Zinc ore | 12 | 52,652 | 3,836.77 | 92,264 | 272,747 | 275,396 | 10,307,060 |
| Copper-lead ore | 27 | 3,900 | 36.28 | 30,476 | 328,731 | 931,520 | ..... |
| Lead-zinc ore | 8 | 55,956 | 2,033.44 | 159,247 | 38,019 | 5,540,329 | 7,945,532 |
| Copper-zinc ore | 2 | 19,280 | 1,528.50 | 45,508 | 541,026 | 85,000 | 17425,357 |
| | ..... | 17,033,810 | 192,801.41 | 7,212,039 | 721,833,169 | 27,062,087 | 19,677,949 |

*Ore sold or treated in Arizona in 1916, in short tons,*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Cochise | 170,641 | 2,099,905 | 59,813 | 26 | 34 | 152 | ..... | 2,330,571 |
| Coconino | ..... | 138 | ..... | ..... | ..... | ..... | ..... | 138 |
| Gila | 102 | 7,766,746 | 622 | ..... | ..... | 220 | ..... | 7,767,690 |
| Graham | 9 | 4,360 | 2,072 | ..... | 85 | ..... | ..... | 6,526 |
| Greenlee | 64 | 2,011,787 | 31 | ..... | ..... | ..... | ..... | 2,011,882 |
| Maricopa | 18,492 | 152 | 27 | ..... | ..... | ..... | ..... | 18,671 |
| Mohave | 98,166 | 3,838 | 1,555 | 50,395 | 13 | 53,569 | ..... | 207,536 |
| Pima | 6 | 168,962 | 1,503 | 313 | 3,141 | ..... | ..... | 173,985 |
| Pinal | 684 | 3,460,476 | 705 | 32 | 95 | 2,015 | ..... | 3,464,007 |
| Santa Cruz | 248 | 9,996 | 6,598 | 1,808 | 457 | ..... | 11,280 | 30,387 |
| Yavapai | 43,733 | 915,009 | 663 | 78 | 75 | ..... | 8,000 | 967,558 |
| Yuma | 4,159 | 50,602 | 98 | ..... | ..... | ..... | ..... | 54,859 |
| | [a] 336,304 | 16,491,971 | 73,747 | 52,652 | 3,900 | 55,956 | 19,280 | 17,033,810 |
| Value per ton in gold and silver | $6.46 | $0.35 | $6.43 | $2.66 | $5.33 | $2.61 | $3.19 | $0.51 |

[a] Includes 164,918 tons of gold ore, 1,470 tons of gold and silver ore, and 169,916 tons of silver ore.

## GOLD.

Arizona ores, placer dust, and bullion in 1916 yielded 192,801.41 ounces of gold, valued at $3,985,559. Of this value, $14,281, against $35,248 in 1915, came from placers; $1,517,616, against $2,157,106 in 1915, from dry or siliceous ore; and $2,180,211, against $1,813,057 in 1915, from copper ores. The mines of Cochise County produced the largest output of gold—$1,514,811 in 1916, against $1,223,882 in 1915. Mohave County was second, with a production of $1,038,814, against $1,626,437 in 1915. The Tom Reed and Gold Road mines were the largest contributors in Mohave County, the Calumet & Arizona and Copper Queen in Cochise County, and the United Verde and Copper Chief in Yavapai County. Gold recovered from ores treated at gold and silver mills represented about 36 per cent of the total production, and crude ores shipped to the smelters about 53 per cent. From ores treated in mills by amalgamation the gold amounted to $113,964, and from ores treated by cyanidation to $1,311,509. Concentrates contained $405,500, as against $384,190 in 1915, and ores shipped directly to smelters contained $2,129,500, against $1,821,171 in 1915. The chief producing districts in 1916 were the Warren district in Cochise

County, where copper ores were produced, and the San Francisco district in Mohave County, where siliceous ores were produced.

*Mine production of gold in Arizona in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|---|
| Cochise | 93.51 | 10,064.36 | 58,418.93 | 4,702.18 | ..... | ..... | ..... | ..... | 73,278.98 |
| Coconino | ..... | ..... | .63 | ..... | ..... | ..... | ..... | ..... | .63 |
| Gila | ..... | 214.49 | 4,759.73 | 521.86 | ..... | ..... | ..... | ..... | 5,496.08 |
| Graham | ..... | 8.76 | 8.08 | 6.00 | ..... | 1.01 | ..... | ..... | 23.85 |
| Greenlee | 5.32 | 26.84 | 2,415.33 | ..... | ..... | ..... | ..... | ..... | 2,447.49 |
| Maricopa | 19.93 | 2,555.12 | 50.16 | ..... | ..... | ..... | ..... | ..... | 2,625.21 |
| Mohave | ..... | 44,283.79 | 3.22 | 199.92 | 3,825.14 | .11 | 1,940.45 | ..... | 50,252.63 |
| Pima | 85.77 | 3.48 | 47.59 | 89.44 | ..... | 11.00 | ..... | ..... | 237.28 |
| Pinal | 10.84 | 326.36 | 4,120.16 | 12.99 | ..... | 2.00 | 92.99 | ..... | 4,565.34 |
| Santa Cruz | ..... | 179.19 | 86.82 | 31.31 | ..... | 21.37 | ..... | ..... | 318.69 |
| Yavapai | 173.18 | 14,008.86 | 34,134.34 | 227.80 | 11.63 | .79 | ..... | 1,528.50 | 50,085.10 |
| Yuma | 302.29 | 1,743.42 | 1,422.72 | 1.70 | ..... | ..... | ..... | ..... | 3,470.13 |
| | 690.84 | [a] 73,414.67 | 105,467.71 | 5,793.20 | 3,836.77 | 36.28 | 2,033.44 | 1,528.50 | 192,801.41 |

[a] Includes 63,562.20 ounces from gold ore, 994 ounces from gold and silver ore, and 8,858.47 ounces from silver ore.

## SILVER.

The mine output of silver in Arizona increased from 5,649,020 ounces, valued at $2,864,053, in 1915, to 7,212,039 ounces, valued at $4,745,522, in 1916. Of this output, 5,347,893 ounces came from copper ore, 997,372 ounces from dry or siliceous ore, 539,108 ounces from lead ore, 159,247 ounces from lead-zinc ore, and smaller quantities from zinc, copper-lead, and copper-zinc ores. The greatest increase of silver was in Cochise, Yavapai, Pinal, and Gila counties, principally from copper ores. Bullion recovered from gold and silver ores, principally by cyanidation (648,382 ounces), yielded 658,830 ounces of silver in 1916. Concentrates contained 1,179,552 ounces, and crude ore shipped to smelters contained 5,305,608 ounces, representing more than 73 per cent of the total output. Cochise County mines led in output of silver, producing 3,709,225 ounces of silver in 1916, against 3,034,714 ounces in 1915, 2,753,953 ounces in 1914, and 2,127,171 ounces in 1913. Yavapai County produced 1,735,302 ounces of silver in 1916, against 1,343,363 ounces in 1915.

*Mine production of silver in Arizona in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|---|
| Cochise | 20 | 776,279 | 2,478,568 | 454,175 | ..... | 48 | 135 | ..... | 3,709,225 |
| Coconino | ..... | ..... | 455 | ..... | ..... | ..... | ..... | ..... | 455 |
| Gila | ..... | 8,727 | 496,685 | 3,164 | ..... | ..... | ..... | ..... | 508,576 |
| Graham | ..... | 3 | 2,989 | 16,119 | ..... | 187 | ..... | ..... | 19,298 |
| Greenlee | 2 | 1,178 | 89,548 | 31 | ..... | ..... | ..... | ..... | 90,759 |
| Maricopa | 2 | 2,735 | 452 | 218 | ..... | ..... | ..... | ..... | 3,407 |
| Mohave | ..... | 41,160 | 1,510 | 6,274 | 80,180 | 339 | 140,730 | ..... | 270,193 |
| Pima | 40 | 103 | 143,708 | 9,295 | ..... | 23,788 | ..... | ..... | 176,934 |
| Pinal | 2 | 1,100 | 592,583 | 10,545 | ..... | 944 | 18,382 | ..... | 623,556 |
| Santa Cruz | ..... | 4,128 | 16,468 | 14,371 | 11,088 | 4,660 | ..... | 19,016 | 69,731 |
| Yavapai | 44 | 160,703 | 1,523,417 | 23,140 | 996 | 510 | ..... | 26,492 | 1,735,302 |
| Yuma | 61 | 1,256 | 1,510 | 1,776 | ..... | ..... | ..... | ..... | 4,603 |
| | 171 | [a] 997,372 | 5,347,893 | 539,108 | 92,264 | 30,476 | 159,247 | 45,508 | 7,212,039 |

[a] Includes 145,713 ounces from gold ore, 32,218 ounces from gold and silver ore, and 819,441 ounces from silver ore.

## COPPER.

A labor strike in the Clifton-Morenci district of Greenlee County affected the output of copper in Arizona in 1916. However, a record output of 721,833,169 pounds was made, valued at $177,570,960, in 1916, against 459,972,295 pounds, valued at $80,495,152, in 1915. Crude ore shipped directly to the smelters yielded 385,569,908 pounds, or more than 53 per cent of the total quantity, against 267,995,345 pounds in 1915. Of the output from crude ore smelted in 1916, Cochise County produced about 52 per cent. Yavapai, Gila, Greenlee, and Pima counties also produced large quanties. The copper in concentrates produced at milling plants increased from 187,731,353 pounds in 1915 to 331,133,062 pounds in 1916. This increase was principally in Gila, Greenlee, and Pinal counties. Gila County, including the Globe and Miami districts, produced altogether 189,299,027 pounds in concentrates, against 77,085,710 pounds in 1915, 73,488,162 pounds in 1914, 71,609,847 pounds in 1913, 63,969,423 pounds in 1912, and 49,226,341 pounds in 1911. The low-grade disseminated ores in Pinal and Gila counties yielded 244,675,654 pounds of copper, against 124,264,911 pounds in 1915, 95,485,293 pounds in 1914, 87,073,406 pounds in 1913, 68,753,553 pounds in 1912, and 30,666,515 pounds in 1911. Similar low-grade copper deposits exist in Greenlee County, whose output added made the total production from the disseminated deposits in Arizona 299,704,303 pounds, or more than 41 per cent of Arizona's copper output in 1916. In 1915 these ores altogether produced 164,483,500 pounds of copper.

*Mine production of copper in Arizona in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Cochise | 136,245 | 202,796,725 | 716,708 | ..... | 2,233 | ..... | ..... | 203,651,911 |
| Coconino | ..... | 41,813 | ..... | ..... | ..... | ..... | ..... | 41,813 |
| Gila | 895 | 225,106,617 | 3,386 | ..... | ..... | ..... | ..... | 225,110,898 |
| Graham | ..... | 278,768 | 32,141 | ..... | 13,933 | ..... | ..... | 324,842 |
| Greenlee | 245 | 75,976,586 | ..... | ..... | ..... | ..... | ..... | 75,976,831 |
| Maricopa | 7,966 | 26,518 | ..... | ..... | ..... | ..... | ..... | 34,484 |
| Mohave | 1,488 | 1,084,511 | 592 | 147,273 | 2,080 | 34,107 | ..... | 1,270,051 |
| Pima | ..... | 12,852,020 | 22,306 | ..... | 236,231 | ..... | ..... | 13,110,557 |
| Pinal | 26 | 86,141,820 | 451 | ..... | 12,201 | 3,912 | ..... | 86,158,410 |
| Santa Cruz | 1,552 | 1,524,170 | 8,431 | 125,474 | 38,515 | ..... | 426,447 | 2,124,589 |
| Yavapai | 14,240 | 109,370,542 | 2,819 | ..... | 23,538 | ..... | 114,579 | 109,525,718 |
| Yuma | 240 | 4,502,699 | 126 | ..... | ..... | ..... | ..... | 4,503,065 |
| | [a] 162,897 | 719,702,789 | 786,960 | 272,747 | 328,731 | 38,019 | 541,026 | 721,833,169 |

[a] Includes 15,760 pounds from gold ore, 11,511 pounds from gold and silver ore, and 135,626 pounds from silver ore.

## LEAD.

The mine production of lead in Arizona in 1916 was 27,062,087 pounds, valued at $1,867,284, against 21,738,969 pounds, valued at $1,021,732, in 1915. Cochise County, principally the Warren or Bisbee district, had the largest yield of lead, or 15,902,137 pounds, valued at $1,097,247, as against 13,129,004 pounds, valued at $617,063, in 1915. Mohave County followed with 5,849,842 pounds and Graham County with 2,171,001 pounds. Concentrates derived from low-grade ores produced 7,192,483 pounds of lead, and crude ores shipped directly to smelters produced 19,869,604 pounds.

*Mine production of lead in Arizona in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Cochise | 6,935 | 5,021 | 15,858,687 | ..... | 4,514 | 26,980 | ..... | 15,902,137 |
| Gila | 514 | ..... | 200,482 | ..... | ..... | 31,606 | ..... | 232,602 |
| Graham | ..... | 7,064 | 2,155,666 | ..... | 8,271 | ..... | ..... | 2,171,001 |
| Greenlee | ..... | ..... | 8,540 | ..... | ..... | ..... | ..... | 8,540 |
| Maricopa | 66,060 | ..... | 30,744 | ..... | ..... | ..... | ..... | 96,804 |
| Mohave | 13,862 | ..... | 163,275 | 271,183 | 7,079 | 5,394,443 | ..... | 5,849,842 |
| Pima | ..... | 7,509 | 288,604 | ..... | 762,032 | ..... | ..... | 1,058,145 |
| Pinal | ..... | 1,099 | 79,380 | ..... | 38,536 | 87,300 | ..... | 206,315 |
| Santa Cruz | 955 | 5,169 | 964,687 | ..... | 102,172 | ..... | 85,000 | 1,157,983 |
| Yavapai | 26,163 | 1,638 | 224,093 | 4,213 | 8,916 | ..... | ..... | 265,023 |
| Yuma | ..... | ..... | 113,695 | ..... | ..... | ..... | ..... | 113,695 |
| | [a] 114,489 | 27,500 | 20,087,853 | 275,396 | 931,520 | 5,540,329 | 85,000 | 27,062,087 |

[a] Includes 84,207 pounds from gold ore and 30,282 pounds from silver ore.

## ZINC.

The mine output of recoverable zinc from Arizona zinc-bearing ores in 1916 amounted to 19,677,949 pounds, valued at $2,636,845, against 18,220,863 pounds, valued at $2,259,387, in 1915. Most of the zinc ore and lead-zinc ore was mined in Mohave County at Union Pass and Chloride. Santa Cruz and Yavapai counties contributed zinc from both zinc ore and copper-zinc ore. Ores milled yielded 18,309,178 pounds of zinc from concentrates, the remainder being from first-class ore. Smaller quantities of ore containing zinc were mined in Cochise, Pima, Pinal, and Gila counties.

*Mine production of recoverable zinc in Arizona in 1916, in dry pounds.*

| County. | Zinc ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|
| Cochise | 13,193 | 59,510 | ..... | 72,703 |
| Gila | ..... | 59,646 | ..... | 59,646 |
| Mohave | 9,499,972 | 7,547,145 | ..... | 17,047,117 |
| Pima | 126,250 | ..... | ..... | 126,250 |
| Pinal | 19,826 | 279,231 | ..... | 299,057 |
| Santa Cruz | 601,846 | ..... | 887,589 | 1,489,435 |
| Yavapai | 45,973 | ..... | 537,768 | 583,741 |
| | 10,307,060 | 7,945,532 | 1,425,357 | 19,677,949 |

*Zinc ore and concentrate from Arizona mines and mills sold in 1916.*

| Classification. | County. | Quantity. | Average assay of ore and concentrate.[a] |
|---|---|---|---|
| | | *Short tons.* | *Per cent of zinc.* |
| Sulphide zinc ore | Mohave, Pima, Pinal, Santa Cruz, and Yavapai. | 2,645 | 25.61 |
| Sulphide lead-zinc ore | Cochise and Gila | 155 | 19.83 |
| Oxidized zinc ore | Cochise and Pima | 284 | 20.27 |
| Oxidized lead-zinc ore | Cochise and Gila | 217 | 18.14 |
| Zinc concentrates | Mohave, Pinal, Santa Cruz, and Yavapai | 28,531 | 37.80 |
| Lead-zinc concentrates | Mohave | 23 | 18.14 |
| Total ore and concentrates | ..... | 31,855 | 36.40 |

[a] Actual assay content.

## MINING INDUSTRY.

A labor strike in the Clifton-Morenci district continued from September 11, 1915, through January, 1916, and caused an estimated loss of 30,000,000 pounds of copper that might have been added to the State total had 5,000 employees remained at work. The general rise in the scale of wages broke all records for Arizona mining, when, with 25-cent copper, the larger companies announced $4.85 a day for shovelers and $5.10 for miners.

The Sasco smelter, near Silver Bell, was again blown in. The railroad from Gila Bend to Ajo was completed, and leaching of copper ore was carried on at the New Cornelia mine in a 400-ton experimental plant, and the 5,000-ton plant was 90 per cent completed. In the Jerome camp exploration work done in old mines has revealed new ore bodies, and important discoveries were made in new ground not previously prospected.

## REDUCTION MILLS.

Milling plants of various kinds to the number of 38 were in operation in Arizona in 1916, only a few continuously. Five mills used straight amalgamation; 3, amalgamation and concentration; 3, amalgamation and cyanidation; 3, only cyanidation; 1, concentration and cyanidation; 2, amalgamation, concentration, and cyanidation; 21, concentration, of which 11 were equipped with the oil flotation process and 1 used straight flotation only. In addition there were 2 leaching plants and 1 precipitating plant for copper water. A list giving all the mills in commission, including many new plants under construction in 1911 and 1912, was published in Mineral Resources for 1911, Part I, page 426.

The ore treated in 1916 by amalgamation amounted to 17,568 tons and produced 5,512.96 ounces of gold and 10,448 ounces of silver, an average recovery per ton of $6.49 in gold and 0.59 ounce of silver. Ores treated by cyanidation amounted to 258,271 tons, which, with 18,352 tons of old tailings, produced 63,444.29 ounces of gold and 648,382 ounces of silver, or an average recovery per ton from ore and tailings of $4.74 in gold and 2.34 ounces of silver. The total value of the bullion recovered from ore and tailings was $1,858,983, as against $2,297,731 in 1915. During 1916 there were 645 pounds of quicksilver and 216,841 pounds of sodium cyanide consumed at milling plants. This corresponds to 0.040 pound of mercury per ounce of gold and silver and 0.037 pound of mercury per ton of ore treated. The consumption of cyanide was 0.30 pound per ounce of gold and silver and 0.78 pound per ton of ore and tailings treated.

*Gold and silver produced at mills in Arizona in 1916.*

| County. | Ore. | Bullion recovered from ore by— | | | | Total value. |
|---|---|---|---|---|---|---|
| | | Amalgamation. | | Cyanidation. | | |
| | | Gold. | Silver. | Gold. | Silver. | |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | |
| Cochise | 130,193 | 150.21 | 7,086 | 7,943.12 | 510,800 | $508,073 |
| Gila | 11 | 136.14 | 25 | ..... | ..... | 2,831 |
| Graham | 9 | 8.76 | 3 | ..... | ..... | 183 |
| Greenlee | 20 | ..... | ..... | 17.85 | 2 | 370 |
| Maricopa | 764 | 1,079.94 | 1,321 | [a] 235.25 | [a] 179 | 28,174 |
| Mohave | 97,143 | 1,047.40 | 638 | [b] 42,876.29 | [b] 24,441 | 924,485 |
| Pima | 5 | ..... | ..... | .12 | 70 | 49 |
| Pinal | 679 | 321.92 | 296 | .84 | 28 | 6,885 |
| Santa Cruz | [c] 189 | 94.40 | 33 | 80.76 | 63 | 3,684 |
| Yavapai | [d] 42,746 | 1,332.30 | 707 | [e] 12,221.77 | [e] 112,627 | 354,762 |
| Yuma | 4,080 | 1,341.89 | 339 | 68.29 | 172 | 29,487 |
| | 275,839 | 5,512.96 | 10,448 | 63,444.29 | 648,382 | 1,858,983 |

[a] Produced from 17,670 tons of old tailings.
[b] Includes bullion from 625 tons of old tailings.
[c] Also yielded 1 ton of concentrate.
[d] Also yielded 117 tons of concentrate.
[e] Includes bullion from 57 tons of old tailings.

Concentration plants reduced 12,851,367 tons of ore to 853,576 tons of concentrates, which were shipped to smelters and produced $405,500 in gold, 1,179,552 ounces of silver, 331,133,062 pounds of copper (or nearly 46 per cent of the total output of copper in the State), 7,192,483 pounds of lead, and 18,309,178 pounds of recoverable zinc, valued in all at $85,590,089, a total average value per ton of $100.27. Copper concentrates amounting to 812,872 tons comprised more than 95 per cent of the total concentrates produced.

*Mine production of metals from Arizona concentrates in 1916.*

**By counties.**

| County. | Ore to concentrating mills. | Concentrates produced. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value of concentrates. |
|---|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Cochise | 20,225 | 1,499 | 408.84 | 36,727 | 50,302 | 441,014 | ..... | $75,422 |
| Gila | 7,412,701 | 346,281 | 2,916.26 | 312,626 | 189,299,027 | 4,778 | ..... | 46,833,883 |
| Graham | 2,648 | 114 | 3.00 | 788 | 58,697 | 7,064 | ..... | 15,507 |
| Greenlee | 1,791,458 | 238,542 | 1,979.00 | 67,011 | 58,733,177 | ..... | ..... | 14,533,365 |
| Maricopa | ..... | 277 | 951.97 | 1,117 | 6,543 | 62,346 | ..... | 26,325 |
| Mohave | 100,363 | 34,086 | 5,759.36 | 219,672 | 172,500 | 5,664,698 | 16,604,590 | 2,921,915 |
| Pima | 1,076 | 221 | 80.00 | 748 | 3,638 | 103,533 | ..... | 10,184 |
| Pinal | 3,409,582 | 210,180 | 3,188.98 | 417,268 | 78,710,060 | 113,776 | 279,231 | 19,748,427 |
| Santa Cruz | 17,272 | 4,534 | 19.70 | 28,091 | 428,362 | 765,526 | 887,589 | 296,026 |
| Yavapai | 96,042 | 17,842 | 4,308.94 | 95,504 | 3,670,756 | 29,748 | 537,768 | 1,129,035 |
| | 12,851,367 | 853,576 | 19,616.05 | 1,179,552 | 331,133,062 | 7,192,483 | 18,309,178 | 85,590,089 |

**By kinds of concentrates.**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dry or siliceous | | 119 | 249.67 | 878 | 2,460 | 1,372 | ..... | $6,441 |
| Copper | | 812,872 | 11,599.07 | 867,993 | 330,897,127 | 7,064 | ..... | 82,212,093 |
| Lead | | 11,998 | 3,467.26 | 192,753 | 55,335 | 6,740,728 | ..... | 677,228 |
| Zinc | | 28,531 | 4,287.71 | 117,291 | 174,393 | 426,727 | 18,302,086 | 2,690,637 |
| Copper-lead | | 33 | 1.00 | 403 | 3,463 | 9,176 | ..... | 1,771 |
| Lead-zinc | | 23 | 11.36 | 234 | 278 | 7,416 | 7,092 | 1,919 |

Of the material smelted, the crude ore was the largest part—3,773,733 tons. It contained the following quantities of recoverable metals: 103,014.57 ounces, or $2,129,500 in gold; 5,305,608 ounces of silver; 385,569,908 pounds of copper; 19,869,604 pounds of lead; and 1,368,771 pounds of zinc, valued in all at $102,025,205, or an average value per ton of $27.01. The copper ores constituted the largest part of the crude ores smelted, aggregating 3,701,716 tons, of which the Warren or Bisbee district, in Cochise County, produced more than 50 per cent. The lead ores formed the next largest quantity—46,930 tons, followed by dry or siliceous ores—18,002 tons, the latter being produced largely in the Tombstone district of Cochise County.

*Mine production of metals from Arizona crude ore shipped to smelters in 1916.*

**By counties.**

| County. | Crude ore to smelter. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Cochise | 2,082,496 | 64,443.30 | 3,088,681 | 199,801,938 | 15,461,123 | 72,703 | $53,592,349 |
| Coconino | 138 | .63 | 455 | 41,813 | ..... | ..... | 10,598 |
| Gila | 351,021 | 2,408.32 | 194,147 | 35,618,270 | 227,824 | 59,646 | 8,963,340 |
| Graham | 3,869 | 12.09 | 18,507 | 266,145 | 2,163,937 | ..... | 227,212 |
| Greenlee | 220,404 | 445.32 | 23,744 | 17,098,654 | 8,540 | ..... | 4,231,688 |
| Maricopa | 237 | 338.12 | 788 | 27,941 | 34,458 | ..... | 16,759 |
| Mohave | 5,400 | 322.26 | 25,253 | 1,097,551 | 185,144 | 442,527 | 365,350 |
| Pima | 172,004 | 71.39 | 176,076 | 13,078,919 | 954,612 | 126,250 | 3,417,533 |
| Pinal | 53,746 | 1,042.76 | 205,962 | 7,445,090 | 92,539 | 19,826 | 1,997,613 |
| Santa Cruz | 12,926 | 123.81 | 41,544 | 1,696,227 | 392,457 | 601,846 | 554,894 |
| Yavapai | 820,713 | 32,048.91 | 1,526,420 | 104,894,295 | 235,275 | 45,973 | 27,493,285 |
| Yuma | 50,779 | 1,757.66 | 4,031 | 4,503,065 | 113,695 | ..... | 1,154,584 |
| | 3,773,733 | 103,014.57 | 5,305,608 | 385,569,908 | 19,869,604 | 1,368,771 | 102,025,205 |
| **By kinds of ore.** | | | | | | | |
| Dry or siliceous | 18,002 | 2,755.60 | 275,609 | 153,888 | 48,461 | ..... | 279,514 |
| Copper | 3,701,716 | 95,046.80 | 4,499,551 | 384,180,489 | 20,436 | ..... | 99,435,306 |
| Lead | 46,930 | 5,151.86 | 485,292 | 775,633 | 18,799,174 | ..... | 1,913,769 |
| Zinc | 2,929 | 24.04 | 14,676 | 134,354 | 17,533 | 1,249,615 | 211,863 |
| Copper-lead | 3,784 | 36.27 | 30,345 | 325,544 | 925,414 | ..... | 164,655 |
| Lead-zinc | 372 | ..... | 135 | ..... | 58,586 | 119,156 | 20,098 |

## PRODUCTION BY COUNTIES.

### GENERAL STATEMENT.

The following tables show the State output by counties in 1916, the production of each metal, and the total value; also the production of ore and the average value per ton, by counties, in 1915 and 1916. The tables are followed by a review of the mining industry for each county and each producing mining district.

*Ore sold or treated, number of deep mines producing, and average values of ore per ton in Arizona in 1915 and 1916.*

| County. | Ore sold or treated. | | Number of deep mines producing. | | Average total value per ton.[a] | | Average value per ton in gold and silver.[a] | |
|---|---|---|---|---|---|---|---|---|
| | 1916 | Increase or decrease. | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 |
| | *Short tons.* | *Short tons.* | | | | | | |
| Cochise | 2,330,571 | + 442,136 | 65 | 67 | $17.63 | $23.67 | $1.46 | $1.70 |
| Coconino | 138 | − 62 | 2 | 3 | 64.56 | 76.80 | 6.14 | 2.26 |
| Gila | 7,767,690 | +5,192,041 | 52 | 58 | 7.14 | 7.19 | .10 | .06 |
| Graham | 6,526 | + 6,203 | 7 | 17 | 50.13 | 37.22 | 5.78 | 2.02 |
| Greenlee | 2,011,882 | + 744,983 | 28 | 18 | 7.13 | 9.35 | .07 | .05 |
| Maricopa | 18,671 | − 12,452 | 22 | 22 | 9.63 | 3.82 | 9.09 | 3.00 |
| Mohave | 207,536 | − 19,899 | 35 | 45 | 19.37 | 20.32 | 7.79 | 5.86 |
| Pima | 173,985 | + 138,591 | 49 | 62 | 19.49 | 19.74 | .92 | .69 |
| Pinal | 3,464,007 | + 535,368 | 46 | 45 | 4.14 | 6.28 | .09 | .15 |
| Santa Cruz | 30,387 | + 16,027 | 27 | 34 | 20.37 | 28.12 | 2.85 | 1.73 |
| Yavapai | 967,558 | + 352,715 | 89 | 88 | 19.25 | 30.19 | 2.37 | 2.25 |
| Yuma | 54,859 | + 25,600 | 46 | 45 | 12.95 | 21.58 | .97 | 1.25 |
| | 17,033,810 | +7,421,251 | 468 | 504 | 9.44 | 11.20 | .73 | .51 |

[a] Placer product excluded.

*Mine production of gold, silver, copper, lead, and zinc in Arizona in 1916.*

| County. | Gold. | | | | | Silver. | |
|---|---|---|---|---|---|---|---|
| | Placers. | | Deep mines. | | Total value. | Quantity. | Value. |
| | Quantity. | Value. | Quantity. | Value. | | | |
| | *Fine ozs.* | | *Fine ozs.* | | | *Fine ozs.* | |
| Cochise | 93.51 | $1,933 | 73,185.47 | $1,512,878 | $1,514,811 | 3,709,225 | $2,440,670 |
| Coconino | | | .63 | 13 | 13 | 455 | 299 |
| Gila | | | 5,496.08 | 113,614 | 113,614 | 508,576 | 334,643 |
| Graham | | | 23.85 | 493 | 493 | 19,298 | 12,698 |
| Greenlee | 5.32 | 110 | 2,442.17 | 50,484 | 50,594 | 90,759 | 59,719 |
| Maricopa | 19.93 | 412 | 2,605.28 | 53,856 | 54,268 | 3,407 | 2,242 |
| Mohave | | | 50,252.63 | 1,038,814 | 1,038,814 | 270,193 | 177,787 |
| Pima | 85.77 | 1,773 | 151.51 | 3,132 | 4,905 | 176,934 | 116,423 |
| Pinal | 10.84 | 224 | 4,554.50 | 94,150 | 94,374 | 623,556 | 410,300 |
| Santa Cruz | | | 318.69 | 6,588 | 6,588 | 69,731 | 45,883 |
| Yavapai | 173.18 | 3,580 | 49,911.92 | 1,031,771 | 1,035,351 | 1,735,302 | 1,141,829 |
| Yuma | 302.29 | 6,249 | 3,167.84 | 65,485 | 71,734 | 4,603 | 3,029 |
| | 690.84 | 14,281 | 192,110.57 | 3,971,278 | 3,985,559 | 7,212,039 | 4,745,522 |

| County. | Copper. | | Lead. | | Recoverable zinc content. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Cochise | 203,651,911 | $50,098,370 | 15,902,137 | $1,097,247 | 72,703 | $9,742 | $55,160,840 |
| Coconino | 41,813 | 10,826 | | | | | 10,598 |
| Gila | 225,110,898 | 55,377,281 | 232,602 | 16,050 | 59,646 | 7,993 | 55,849,581 |
| Graham | 324,842 | 79,911 | 2,171,001 | 149,799 | | | 242,901 |
| Greenlee | 75,976,831 | 18,690,300 | 8,540 | 589 | | | 18,801,202 |
| Maricopa | 34,484 | 8,483 | 96,804 | 6,679 | | | 71,672 |
| Mohave | 1,270,051 | 312,433 | 5,849,842 | 403,639 | 17,047,117 | 2,284,314 | 4,216,987 |
| Pima | 13,110,557 | 3,225,197 | 1,058,145 | 73,012 | 126,250 | 16,917 | 3,436,454 |
| Pinal | 86,158,410 | 21,194,969 | 206,315 | 14,236 | 299,057 | 40,074 | 21,753,953 |
| Santa Cruz | 2,124,589 | 522,649 | 1,157,983 | 79,901 | 1,489,435 | 199,584 | 854,605 |
| Yavapai | 109,525,718 | 26,943,327 | 265,023 | 18,287 | 583,741 | 78,221 | 29,217,015 |
| Yuma | 4,503,065 | 1,107,754 | 113,695 | 7,845 | | | 1,190,362 |
| | 721,833,169 | 177,570,960 | 27,062,087 | 1,867,284 | 19,677,949 | 2,636,845 | 190,806,170 |

## COCHISE COUNTY.

*Mine production in Cochise County, Ariz., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 67 | 1,888,435 | $1,223,882 | 3,034,714 | 170,887,812 | 13,129,004 | 87,705 | $33,295,788 |
| 1916 | 69 | 2,330,571 | 1,514,811 | 3,709,225 | 203,651,911 | 15,902,137 | 72,703 | 55,160,840 |
| Increase or decrease, 1916 | | +442,136 | +290,929 | +674,511 | +32,764,099 | +2,773,133 | −15,002 | +21,865,052 |

[a] Includes small placer production.

The total average value per ton of the ore increased from $17.63 in 1915 to $23.67 in 1916, and the gold and silver value in this ore increased from $1.46 to $1.70. All of the metals, with the exception of zinc, showed an increase in quantity and value. Gold, valued at $1,223,882 in 1915, increased to $1,514,811 in 1916; silver from $1,538,600 in 1915 to $2,440,670 in 1916; copper from $29,905,367 in 1915 to $50,098,370 in 1916; lead from $617,063 in 1915 to $1,097,247. Recoverable zinc, which had a value of $10,876 in 1915, decreased to $9,742 in 1916. Ores of smelting grade, of which there were 2,082,496 tons, predominated and contained $1,332,161 in gold, 3,088,681 ounces of silver, 199,801,938 pounds of copper, 15,461,123 pounds of lead, and 72,703 pounds of zinc, valued in all at $53,592,349, or an average value per ton of $25.73. The 41,899 tons of lead ores shipped to lead plants outside of the State contained 4,297.18 ounces of gold, 417,910 ounces of silver, 708,291 pounds of copper, and 15,418,183 pounds of lead. Of the copper ore smelted it was estimated that 347,828 tons were oxidized ores and 1,676,199 tons were sulphide ores. Two placer producers reported a production of $1,933 in gold and 20 ounces of silver.

*California district.*—The production from three deep mines aggregated 233 tons, shipped directly to the smelters, and containing $21 in gold, 580 ounces of silver, 2,488 pounds of copper, 54,669 pounds of lead, and 65,035 pounds of recoverable zinc, valued in all at $13,502. The Gardner, Paradise, and Sunset properties were the producers.

*Cochise or Johnson district.*—Reports received from 15 deep-mine operators showed a production in 1916 of 82,133 tons of ore, containing $605 in gold, 61,430 ounces of silver, 6,204,459 pounds of copper, and 29,212 pounds of lead, valued in all at $1,569,339, or an average value per ton of $19.11. All of the ore, with the exception of 120 tons containing a small quantity of gold and silver, was of smelting grade. In 1915 the output aggregated 44,636 tons, having a total value of $688,579. The principal part of the production, largely sulphide copper ore, came from the Republic property. Other producers of importance were the properties worked by the Arizona & Michigan Development Co. and the Peabody Consolidated Co. Some oxidized copper ore carrying silver was shipped from the Black Prince mine. The other producers were the Centurion and Keystone properties.

The output of the Golden Rule and Middlemarch properties is included in this district.

*Dos Cabezas district.*—The principal producer of the district was the Mascot Copper Co., which shipped a low-grade copper sulphide ore directly to the smelters.

There was also some gold and silver ore shipped from the Henry Clay and the Casey claims. The ore from the Silver Dike property contained principally gold, with a little silver, lead, and copper. The total output of the district, including that of two operators of surface mines, was valued at $99,964, the larger part of this being for the copper contained in the ore produced.

*Hartford or Huachuca district.*—There were 128 tons of ore produced from six properties and shipped directly to the smelters, which contained principally copper, with a little lead, gold, and silver. Copper ore was reported from the Pearl and Copper King mines, and the remainder was reported from various prospects in the region.

*Rincon Mountains district.*—The Happy Valley prospect in this district, situated northwest of Benson, yielded copper ore containing a little silver, which was shipped directly to the smelter.

*Teviston district.*—The production of ore credited to three properties in the region contained a small quantity of gold. There was also a little lead, copper, and zinc produced.

*Tombstone district.*—Five producers reported the output in 1916 of 57,200 tons of ore, 20,197 tons of which, containing gold, silver, and lead, were shipped directly to the smelters, and 20,426 tons were treated at mills and yielded gold and silver bullion. In addition to this, 16,577 tons of ore of milling grade produced 684 tons of lead concentrate, containing gold and silver. The total value of the production of the district was $411,592, recovered principally from the ores mined from the Tombstone group of the Bunker Hill Mines Co. Manganese ore and concentrate was shipped in considerable quantity from this property to Douglas and to metallurgic plants in the East.

Development work in this property [1] was carried out in the ground above water level and no attempt was made to explore below. Prospecting the old workings was continued with encouraging results. The assays of the ores loaded and broken in the stopes were as follows:

*Assays of ores from Tombstone mines.*

| | Loaded. | Broken in stopes. | Assays. | | | | |
|---|---|---|---|---|---|---|---|
| | | | Gold. | Silver. | Copper. | Manganese. | Lead. |
| Milling ores: | *Dry tons.* | *Dry tons.* | *Ounces.* | *Ounces.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Gold-silver | 19,099 | 7,992 | 0.104 | 6.51 | ..... | ..... | 2.0 |
| Silver-manganese | 14,879 | 620 | .015 | 11.80 | 0.41 | 23.4 | ..... |
| Do | ..... | 1,422 | .010 | 5.90 | .40 | 19.5 | ..... |
| Manganese | 1,608 | ..... | .015 | 3.82 | .35 | 46.3 | ..... |
| Wulfenite | 1,127 | 290 | .048 | 4.79 | (a) | ..... | 3.98 |
| Smelting ores: | | | | | | | |
| Siliceous | 1,470 | ..... | .680 | 21.92 | .39 | ..... | ..... |
| Flux | 5,955 | 460 | .043 | 12.21 | .43 | ..... | ..... |
| Lead | 4,345 | 32 | .260 | 14.50 | ..... | ..... | 9.5 |

a 0.78 per cent ($MoO_3$).

[1] Phelps, Dodge & Co. Ann. Rept. for year ending Dec. 31, 1916.

The company's annual report contains further information, as follows:

The experimental work for the treatment of the low-grade gold, silver, and lead ores was actively pursued along the general lines of amalgamation, hydraulic concentration, and segregation of the different mineral constituents of our very complex material. The greatly increased cost of cyanide and the rather low extraction of the precious metals obtained in the past made it necessary that some cheaper and more efficient method should be devised if the large tonnage of these ores now developed is to be made commercially profitable. Our experiments to date have been distinctly encouraging.

A unit of the mill was also used for the treatment of manganese ores, resulting in the production of manganese concentrates, ranging between 70 and 85 per cent manganese dioxide, and tailings marketable as silver-bearing flux or steel furnace alloys.

There were treated during the year 36,913 tons of ore, as follows:

| | Dry weight. | Average assays. | | | |
|---|---|---|---|---|---|
| | | Gold. | Silver. | Lead. | Manganese. |
| | *Short tons.* | *Ounces.* | *Ounces.* | *Per cent.* | *Per cent.* |
| Cyaniding department | 20,426 | 0.100 | 6.37 | 2.03 | ..... |
| Concentrating department | 16,487 | .015 | 9.90 | ..... | 24.3 |

The total shipments were as follows:

| | Dry weight. | | Gold. | Silver. | Lead. | Copper. | Molybdenum-trioxide. |
|---|---|---|---|---|---|---|---|
| | *Ounces.* | *Short tons.* | *Ounces.* | *Ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Bullion | 92,478 | ..... | 1,014 | 58,521 | ..... | ..... | ..... |
| Lead concentrates | ..... | 681 | 388 | 31,399 | 154,952 | ..... | ..... |
| Lead ores | ..... | 4,345 | 1,156 | 62,941 | 827,827 | ..... | ..... |
| Wulfenite | ..... | 1 | 1 | 18 | 1,204 | ..... | 279 |
| Silver manganese | ..... | 8,279 | 141 | 85,526 | ..... | 68,974 | ..... |
| Siliceous ores | ..... | 1,470 | 994 | 32,218 | ..... | 11,511 | ..... |
| Flux ores | ..... | 5,956 | 256 | 72,830 | ..... | 51,061 | ..... |
| | 92,478 | 20,732 | 3,950 | 343,453 | 983,983 | 131,546 | 279 |

| | Dry weight. | Manganese. | Manganese dioxide. |
|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Pounds.* |
| Manganese ore | 1,199 | 1,061,409 | ..... |
| Manganese dioxide ore | 1,295 | ..... | 1,8.2,0.2 |

*Turquoise district.*—The reports of 13 producers in the district showed the output of 189,501 tons of ore, containing $178,797 in gold, 588,881 ounces of silver, 3,251,394 pounds of copper, and 206,306 pounds of lead, valued in all at $1,380,359, or an average value per ton of $7.28. The principal part or 109,639 tons was milled, producing gold and silver, and the remainder (55,862 tons), containing gold, silver, copper, and lead, was shipped directly to the smelters. In addition to the ore mined, there were 24,000 tons of old tailings containing a small quantity of gold and silver sold as silica for converter lining at the smelters. The Commonwealth property continued to be the largest producer of gold and silver, which were extracted from the

ore in a 30-stamp mill and cyanide plant having a capacity of 350 tons of ore per day. Among the principal copper producers were the Mary & Mamie, Maid of Sunshine, Copper Bell, Germania, and Copper Rocks. The Tejon property produced oxidized lead and copper ore, containing gold and silver.

*Warren or Bisbee district.*—From 10 properties in the district there were produced 1,996,408 tons of ore, containing $1,244,222 in gold, 2,703,270 ounces of silver, 193,696,431 pounds of copper, and 14,580,802 pounds of lead, valued in all at $51,678,371, or an average value per ton of $25.89. All the ore, with the exception of 3,650 tons, was of smelting grade. There were also shipped to the smelters 73,657 tons of old slag, containing copper and silver. Most of the ore, containing copper, was treated at Douglas, Ariz., and the lead ore was shipped to El Paso, Tex.

The Calumet & Arizona mines[1] produced 810,938 dry tons of copper ore, which was smelted at the company's plant at Douglas, and 35,785 tons of low-grade sulphide copper ore, which were shipped to the smelters at Miami and Sasco, and upon which a premium on high iron and sulphur contents was received in addition to the usual payments for copper, gold, and silver. At Douglas the company smelted, in addition to its own ores, 275,581 tons of custom ore. During 1916 the mines and smelter were operated practically up to capacity. There was produced from the company ore sold or treated 70,702,028 pounds of copper, 1,267,734 ounces of silver, and 31,673.58 ounces of gold. Dividends were paid amounting to $5,777,296 in 1916. The company gives the following paragraphs in its annual report:

> Precious metals per ton of refined copper from our own ores amounted to $41. The net cost per pound of refined copper after deducting values of precious metals was 9.04 cents. We received an average price of 24.698 cents for all copper delivered during the year. The average selling price for copper sold during the year is considerably above this figure, but covers deliveries of copper to be made during the first half of 1917. * * *
>
> Mining operations at our Bisbee properties during the year were the largest in the company's history. A total of 162,703 more wet tons of ore were mined than in 1915, our best previous record. The amount of development work exceeded that of any other year by nearly 6 miles. In all, we made approximately 25 miles of new openings.
>
> The sliding scale of wages was in effect throughout the year and our employees received the highest wage ever paid in the camp. The maximum wage was reached in December, when miners received $5.85 per day, in contrast with $3.60 per day which they were receiving in December, 1914.
>
> Although we mined and shipped an enormous tonnage, our ore reserves showed very substantial increases for the year.

From the Copper Queen mines[2] 853,279 tons of copper ore were shipped to Douglas, containing 22,898 ounces of gold, 809,911 ounces of silver, and 98,188,475 pounds of copper. To El Paso there were shipped 23,462 tons of lead ore, containing 1,113 ounces of gold, 275,323 ounces of silver, 647,274 pounds of copper, and 9,136,010 pounds of lead. In addition to this output, there were 765 tons of copper precipitates from mine water, also some old dump slag and lead concentrate shipped from the Bisbee mines. The total of all material contained 24,030 ounces of gold, 1,096,136 ounces of silver,

[1] Calumet & Arizona Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] Phelps, Dodge & Co. Ann. Rept. for year ending Dec. 31, 1916.

102,685,722 pounds of copper, and 9,421,562 pounds of lead. The annual report of Phelps, Dodge & Co. gives further information concerning the Copper Queen mine, as follows:

The tonnage and metal content of the ore produced exceeded any previous year in the history of the mine. Notwithstanding the prevailing high price of copper and the consequent low minimum grade permissible, the average copper assay of the ore was 5.76 per cent.

Profitable slag from the lower dump was exhausted before the end of the year, and there remains but a small quantity yet to be reclaimed from the Czar dump.

The quantity of copper recovered from the precipitating plant was much in excess of the previous three years, and the results from this source were very satisfactory.

The shipments of lead ore to the El Paso smelter have been quite uniform both in tonnage and lead content, the grade averaging 19.5 per cent. The amount of this class of ore now developed indicates that the lead output from the district will be of considerable importance in the future.

The total advance in exploration and development work during the year was 80,853 feet, which does not include 46,925 feet of churn drilling on the Sacramento Hill. The proportion of exploration work relative to the tonnage mined was lower than normal, but results show that more ore was found than that extracted, and the estimated reserves stand within a few thousand tons of their maximum.

Rich ore has been discovered in the upper levels of the Southwest on the old Copper King claim. Primary sulphides are becoming of greater importance, and several new bodies of this type of ore have been found in the Gardner division.

Results of churn drill and underground development in Sacramento Hill show the existence of two separate bodies of concentrating ore, known as the west and east ore bodies. It appeared that the west ore body lay sufficiently near the surface to permit mining operations by steam shovel, and after careful study of the entire problem this method of mining has been decided on and the work will be undertaken with as little delay as possible.

To treat this ore a concentrating plant of 3,000 tons daily capacity, with the necessary power equipment, will have to be erected.

The concrete lining of the Sacramento shaft was finished in August without retarding production; in fact, the greatest month's tonnage was in March, when 75,190 tons were hoisted through the shaft while 165 feet of shaft lining was cast.

There have been no active fires during the year, and the condition of areas under suspicion is satisfactory.

The Shattuck-Arizona mine[1] yielded 168,643 dry tons of copper ore shipped to Douglas and 10,069 tons of lead ore treated at El Paso. From these ores there were recovered 18,161,763 pounds of copper, 314,918 ounces of silver, 4,721 ounces of gold, and 3,413,445 pounds of lead. The company's report contains the following paragraphs:

The ore output for the year averaged slightly less than 600 tons daily for each working day. Advantage was taken of the prevailing high price of copper metal to mine a large tonnage of low-grade copper ores which were not marketable in years past.

Copper production was maintained at the average rate of 1,500,000 pounds monthly for the entire year. The increase in production was due to a larger tonnage of ore mined and not at the expense of mining more than normal amounts of high-grade ores.

The slight increase in the net cost per pound of copper was due to mining a lower average grade of ore and to a higher cost of labor and supplies. * * *

There was an increase of 68 per cent in the tons of ore mined over 1915 and an increase of approximately 50 per cent in copper metal production, which resulted in lower costs per ton for operating overhead. However, on account of an increase of approximately 45 per cent in the amount of development work done, an increase of 25 per cent for the year in wages and salaries, and much

[1] Shattuck-Arizona Copper Co. Ann. Rept. for year ending Dec. 31, 1916.

larger increases in the cost of supplies, the total cost per dry ton smelted was the same. The slightly higher gross and net costs per pound were due to the less recovery per dry ton which resulted in mining the lower-grade ores that were made profitable by the high price of copper metal.

Two new and important ore bodies were developed during the year on the 200 and 800 foot levels, respectively. Promising leached ore territories were exposed in a number of places, and these leached zones indicate other ore bodies will be encountered in the near future. The mine is in good condition and we shall continue our present copper output and endeavor to increase lead production during the year 1917.

The lead output was handicapped during mid year by congestion of ores at the smelter. The tonnage shipped was small in comparison to our developed tonnage of first and second class lead ores. * * *

We have an indicated tonnage of approximately 1,000,000 tons of very siliceous oxidized ores of lead assaying 10 to 12 per cent lead, $1 in gold and 6 ounces silver per ton. Experiments to date indicate a profit of $4 per ton of ore can be made. This profit is based on normal market prices of lead and silver. * * *

On the levels of the mine above the 400-foot level, in the course of development work, irregular bunches and small lenses of manganese ores are encountered. Most of the material is below the grade acceptable to manganese ore buyers. We have shipped one carload of 35 tons of sorted ore assaying 45 per cent manganese, and further shipments will be made as long as the present price for manganese remains in effect.

## COCONINO COUNTY.

*Francis district.*—A small quantity of oxidized copper ore was shipped from one property in 1916.

*Grand Canyon district.*—Copper ore containing a little silver and gold was shipped from the Grand Canyon property to the Humboldt smelter.

*Warm Springs district.*—This district is situated in the Buckskin Mountains in the northern part of the county, 160 miles south of Marysvale, Utah. The supply point and headquarters of the operators of the Buckskin property is at Kanab, Utah. A few tons of selected copper carbonate ore were shipped to the smelters near Salt Lake from this property in 1916. As transportation costs are prohibitive, a leaching plant is contemplated.

## GILA COUNTY.

*Mine production in Gila County, Ariz., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ozs.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 52 | 2,575,649 | $85,178 | 328,684 | 103,502,364 | 124,756 | ..... | $18,381,099 |
| 1916 | 58 | 7,767,690 | 113,614 | 508,576 | 225,110,898 | 232,602 | 59,646 | 55,849,581 |
| Increase, 1916 | ..... | 5,192,041 | 28,436 | 179,892 | 121,548,534 | 107,846 | 59,646 | 37,468,482 |

The total average value per ton of the ore sold or treated in Gila County increased from $7.14 in 1915 to $7.19 in 1916, and the gold and silver value per ton decreased from 10 cents to 6 cents. There was increase in the value of all the metals. Gold was valued at $113,614, an increase of $28,436 compared with 1915; silver increased in value from $166,643 to $334,643; copper, from $18,123,414 to

$55,377,281; and lead, from $5,864 to $16,050. There was also a production of zinc in 1916 valued at $7,993. Of the ores produced, 7,412,701 tons were of concentrating grade and produced 346,281 tons of concentrate, containing 2,916.26 ounces of gold, 312,626 ounces of silver, 189,299,027 pounds of copper, and 4,778 pounds of lead. The crude ores, mostly copper ore, shipped directly to the smelters amounted to 351,021 tons, against 189,933 tons in 1915. The crude ores in 1916 contained 2,408.32 ounces of gold, 194,147 ounces of silver, 35,618,270 pounds of copper, 227,824 pounds of lead, and 59,646 pounds of zinc. There were also 483 tons of old copper slag and some flue dust resmelted. Nearly all of this ore was treated in the district, with the exception of the lead ores and some copper ores, which were shipped to plants outside of the county. Of the copper ores smelted, 273,786 tons were oxidized and 76,333 tons were sulphides. The smelting ores shipped were valued at $8,963,340, or an average value per ton of $25.54, and the concentrates, chiefly copper, were valued at $46,833,883, or an average value per ton of $135.24.

*Banner district.*—Nine mining properties yielded 84,640 tons of ore containing $21,958 in gold, 26,065 ounces of silver, 5,041,817 pounds of copper, and 142,344 pounds of lead, valued in all at $1,289,217. All of the ore, with the exception of 5 tons which produced a little gold and silver bullion, was shipped directly to the smelters. There was also a quantity of flue dust containing copper shipped to the smelters. The principal producer was the Christmas property of the Gila Copper Sulphide Co., opened by a vertical shaft 850 feet deep and about 20,000 feet of drifts. The product mined is mixed sulphide and oxidized ores, the latter extending to a depth of 500 feet below the surface. This property was worked during the entire year. Important productions were also made from the London-Arizona, Gila Canyon, Apex, and Standard properties.

*Dripping Springs district.*—The Cowboy & Gladys group of claims was worked and a small quantity of ore treated in a Gardner grinder having a capacity of 1 ton of ore per hour. This little plant turned out bullion containing gold and silver.

*Globe district.*—Thirty-eight properties produced 7,683,015 tons of ore, the larger part of which (7,412,701 tons) was of milling grade and produced 346,281 tons of concentrate containing 2,916.26 ounces of gold, 312,626 ounces of silver, and 189,299,027 pounds of copper. From one property there was a small quantity of lead saved in the concentrate. The smelting ore amounted to 269,831 tons, containing 1,339.35 ounces of gold, 163,319 ounces of silver, 30,739,710 pounds of copper, 85,308 pounds of lead, and 59,646 pounds of recoverable zinc. In addition to this ore, there were 483 tons of old slag and flue dust resmelted which contained copper, gold, and silver.

The Old Dominion mine[1] in 1916 produced 152,059 dry tons of ore, yielding 17,654,643 pounds of fine copper, 60,689 ounces of silver, and 1,240.92 ounces of gold. There were milled 49,715 dry tons of ore, which assayed 3.72 per cent of copper, as compared with 32,560 tons assaying 3.72 per cent in 1915. The smelting ore amounted to 98,761 tons, averaging 7.03 per cent of copper in 1916, as compared with 80,512 tons of 7.81 per cent grade in 1915. Of the siliceous copper

[1] Old Dominion Copper Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1916.

ore, 4,389 tons averaged 3.89 per cent of copper, compared with 2,567 tons averaging 3.65 per cent of copper in 1915. The mining costs per ton were $6.48 against $5.51, and milling $1.14 against $1.21. Dividends paid by this company amounted to $1,944,000 in 1916.

The following notes are taken from the company's annual report:

The tonnage concentrated in 1916 was 81,167 tons in excess of that handled in the previous year. Toward the end of the year the concentrator was working up to its full capacity and doing very excellent metallurgical work. The extraction for 1916 was 86.63 per cent, compared with 85.27 per cent in 1915. With improvements now underway, it is confidently anticipated that the metallurgical saving can be still further improved. The power consumption was reduced considerably during the year. Flotation work showed a great improvement, particularly toward the end of the year. * * *

Notwithstanding the much higher average wage rate effective in 1916, the smelting costs are only slightly increased.

A much larger tonnage of custom, lease, and dump ores were handled by the smelter in 1916 than in former years. We continued to ship all of our flotation concentrates over to the International Smelting Co., at Miami, as well as what surplus gravity concentrates could be spared over and above the requirements of the blast furnaces. * * *

During the year 2,523.87 million gallons of water were pumped from the mine. There were sold to the Miami Copper Co., 732,000,000 gallons. The minimum rate of flow was 4,078,585 gallons per 24 hours, on December 31, and the maximum 11,501,907 gallons per 24 hours, reached on February 27. New centrifugal pumps have been installed, and early in the coming year, when the Diesel engine is running, the pumping plant will have a total capacity of 20,000,000 gallons per day from the twelfth and tenth levels to the surface and the drain tunnel.

At the Inspiration mine[1] 5,353,880 tons of ore were mined in 1916, 21,289 tons being the maximum for any single day. Of the ore mined, 5,322,058 tons were milled, and 1,969 tons of siliceous ore, 18 tons of high-grade ore, and 19,835 tons of oxide-copper ore went directly to the smelter. The total production of copper was 120,772,637 pounds. The total cost of copper derived from concentrating ores was 8.67 cents per pound. The total cost per ton of ore was $1.948. From the annual report of the company the following is taken:

The reserves at December 31, 1916, were 91,789,120 tons. Of this reserve about 20,000,000 tons are to be classified as oxide ores.

During the year active development work was inaugurated to determine the method of treating these oxide ores best adapted to our conditions. Good results were obtained from a leaching scheme which is now being tried out with a small-scale plant erected for that purpose. At the same time attention has been given, with encouraging results, to the problem of recovering a higher percentage of the oxide copper associated with the sulphide ores.

The last unit of the mill was completed February 21, 1917, since which date the entire plant has been in continuous operation.

Results have been highly satisfactory. Mining and milling costs have been low, notwithstanding the exceedingly high cost of all supplies and labor and the natural disadvantages of starting and systematizing such a large operation.

Metallurgical results have been as good as could be expected. Practically 91 per cent of the copper sulphides was saved from an ore assaying 1,548 per cent copper.

Two additional sections, which will soon be in operation, were added, to insure mill capacity of 16,000 tons daily. This tonnage has already been exceeded, and it is safe to say 20 sections will have a daily capacity in excess of 18,000 tons.

The mine is in shape to maintain a daily production of at least 20,000 tons.

The refined-copper production for the year was 120,772,637 pounds, all of which has been sold at an average price of 25.393 cents per pound. * * *

The yield in refined copper per ton of ore was 22.625 pounds.

[1] Inspiration Consolidated Copper Co. Ann. Rept. for year ending Dec. 31, 1916.

Dividends in 1916 amounted to $6,184,117.

From the Miami property[1] there were produced 1,842,017 tons of ore, averaging 2.07 per cent of copper, which was concentrated in the company's mill and the concentrate smelted at the International smelter. There were 66,289 tons of concentrate, averaging 42.49 per cent of copper, representing an extraction of 73.88 per cent, and containing 56,335,103 pounds of copper, from which the smelter returned 53,518,331 pounds of refined copper. The total cost of handling the ore was $1.937 per ton, divided into, mining, $1.118; milling, $0.589; and general expense, $0.229, or a total average per pound of copper of $0.0952. The following extracts are taken from the company's annual report:

Mining of the ore has been carried on by the shrinkage-stope method in the Captain and Northwest ore bodies, and by the top-slicing with timber in the main ore body. * * *

Mine development for the year amounted to 42,118 feet, of which 23,845 feet consisted of drifts and crosscuts and 18,273 feet of raises and winzes. * * *

No addition to the tonnage of high-grade ore was made during the year, and this figure is now 16,400,000 tons, averaging 2.40 per cent copper. In the low-grade ore body some additional drifting was done, and 10,825 feet of additional churn drilling done. In all, 16 new holes were put down and 3 old holes carried to greater depths. The result of this work has been the demonstration of a considerably greater tonnage than was figured in previous years, and it is now estimated that distinct from the older ore body in the mine there is 28,000,000 tons of low-grade ore of an average of 1.06 per cent copper.

No exploratory work was done in the oxidized ore area, this estimate remaining at 6,000,000 tons of partially developed mixed oxide and sulphide ore, averaging about 2 per cent copper.

Dividends paid amounted to $4,295,905.

According to the annual report of the United Globe mines[2] ore extraction and development were confined to the Old Dominion, Grey, and Big Johnnie veins. The quantity and grade of ores extracted and shipped in 1916 compare as follows with the previous year:

*Ore produced from United Globe mines, 1915 and 1916.*

| Kind of ore. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Tons. | Per cent of copper. | Tons. | Per cent of copper. |
| Smelting oxide | 19,112 | 6.90 | 15,378 | 7.16 |
| Smelting sulphide | 292 | 1.01 | ..... | ..... |
| Concentrating ore | 119,537 | 3.63 | 187,280 | 3.28 |
| Silica converter ore | 2,299 | 4.73 | 3,505 | 5.45 |
| | 141,240 | 4.08 | 206,163 | 3.60 |

The following paragraph is taken from the company's report:

The high prices for the metal realized during the year allowed the company to extract ores of a substantially lower tenor than has been possible in recent years. The copper production of the mine was the highest in its history, and in general its operations were conducted on a larger scale than in any preceding year. Development on the lower levels has been kept well ahead of ore extraction, and the outlook for maintaining the present rate of production is

[1] Miami Copper Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] Old Dominion Copper Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1916.

particularly promising. The high wages and increase in cost of materials prevailing during the year of necessity added very considerably to the cost of producing copper.

Dividends paid by the company in 1916 amounted to $1,679,000.

At the Copper Hill and Eureka mines[1] there were produced 29,579 dry tons of smelting ore, 18,252 dry tons of concentrating ore, and 984 tons of siliceous copper ore. These ores averaged in copper, respectively, 5.859 per cent, 3.673 per cent, and 4.832 per cent. In addition, 74.7 tons of secondary smelting product was shipped from the smelter, averaging 9.71 per cent of copper. All of the output in 1916, aggregating 48,889.95 tons, was treated at the Old Dominion and Copper Queen smelters and contained 4,178,474 pounds of copper, 21,163.58 ounces of silver, and 305.38 ounces of gold. The company paid its first dividend in 1916 of $132,500. Considerable new ore of smelting grade was opened on the fourteenth level. The property is opened by a shaft sunk below the fifteenth level. It is confidently believed by the company that it will develop large and favorable ore bodies on the fifteenth and sixteenth levels.

*Green Valley district.*—Six producers reported 18 tons of ore, yielding $770 in gold, 350 ounces of silver, and 3,336 pounds of copper, valued in all at $1,821. The principal properties producing were the West Star, Bell, Ox Bow, Silver Butte, and Silver Glance.

*Gun Creek district.*—A small quantity of free-milling gold ore was mined and treated from one property in the district, which is situated 50 miles north of Globe, near Young, Ariz.

*Richmond Basin district.*—A few tons of ore containing principally silver, with a little gold and lead, was shipped from the Jumbo property, which is opened by about 300 feet of surface drifts. The property is situated 12 miles in a northerly direction from Globe. There was also a small quantity of silver ore shipped from the Martin property.

## GRAHAM COUNTY.

Seventeen producers in the county reported 6.526 tons of ore containing gold, silver, copper and lead, valued at $242,901. Most of this ore was of smelting grade and was produced from the Bunker Hill, Aravaipa, Lone Star, and Stanley Butte districts.

*Aravaipa district.*—Altogether there were 2,061 tons of ore of shipping grade reported by six producers in 1916. The ore contained $186 in gold, 15,893 ounces of silver, 36,239 pounds of copper, and 2,115,117 pounds of lead, valued in all at $165,502, or an average value per ton of $80.30. The largest part of the production came from the property owned by the Aravaipa Mining Co., operated by lessees, who shipped lead carbonate containing a little silver. The Grand Reef property produced lead-silver ore containing a little copper.

*Bunker Hill district.*—Three properties reported to be on the Graham County side of the district yielded 2.714 tons of ore, the principal part of which (2,648 tons) yielded 114 tons of concentrate containing copper and a little lead and silver. The remainder of the output, or 66 tons, containing copper, was shipped directly to the smelters. The producers were the Copper State, New York & California, and the Bleak claims.

[1] Arizona Commercial Mining Co. Ann. Rept. for year ending Dec. 31, 1916.

*Lone Star district.*—Shipping ore, containing principally copper, with some lead and silver, was shipped from the San Juan and Esperanza properties. The Ten Strike and Lone Star properties yielded lead ore with silver values.

*Stanley Butte district.*—The Cobre Grande property, 18 miles west of Geronimo, a station on the Arizona & Eastern R. R., produced a small quantity of copper ore containing a little silver.

## GREENLEE COUNTY.

*Mine production in Greenlee County, Ariz., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ozs.* | *Pounds.* | *Pounds.* | |
| 1915 | 34 | 1,266,899 | $47,884 | 81,210 | 51,096,225 | ..... | $9,030,896 |
| 1916 | 19 | 2,011,882 | 50,594 | 90,759 | 75,976,831 | 8,540 | 18,801,202 |
| Increase, 1916 | ..... | 744,983 | 2,710 | 9,549 | 24,880,606 | 8,540 | 9,770,306 |

[a] Includes placer production.

There were 18 producers of ore and 1 producer of placer bullion in Greenlee County in 1916. The quantity of ore mined was 744,983 tons more than was reported by 28 producers in 1915. The ore sold or treated averaged $9.35 a ton in 1916, against $7.13 a ton in 1915. The gold and silver reported as being recovered from the refining of copper bullion amounted to only 5 cents a ton. The concentrating ores aggregated 1,791,458 tons and produced 238,542 tons of concentrates, which contained $40,910 in gold, 67,011 ounces of silver, and 58,733,177 pounds of copper, valued in all at $14,533,365, or an average value per ton of $60.93. The ore smelted was 220,404 tons, all of which was oxidized except 10,022 tons. Of this total, 220,329 tons were copper ore. The gold output of the placers amounted to $110, against a production of $809 in 1915.

*Copper Mountain and Greenlee districts.*—In 1916 the Detroit mines[1] produced 454,027 tons of concentrating ore assaying 2.39 per cent of copper, which yielded 1.62 per cent of fine copper. There were 11,325 tons of smelting ore treated, assaying 9.40 per cent of copper, from which was recovered 8.97 per cent of fine copper. From this output and 1,659 tons of old slag and tailing and 7,797 tons of siliceous copper ore, averaging 4.58 per cent of copper, to converters, there were produced altogether 17,541,258 pounds of fine copper. A distribution of the tonnage of ore from the various mines and into different classes is taken from the annual report of Phelps, Dodge & Co., as follows:

| Mine. | Total. | Second class. | Sulphide. | Oxide. | Quartz. | Precipitates. | Talc. |
|---|---|---|---|---|---|---|---|
| Ryerson | 213,796 | 210,009 | 3,770 | 17 | ..... | 0.3 | ..... |
| Yankie | 115,986 | 113,560 | 1,294 | 34 | 1,099 | 8.4 | ..... |
| Copper Mountain | 86,336 | 81,904 | 621 | 3,811 | ..... | ..... | ..... |
| Arizona Central | 51,274 | 45,874 | 258 | ..... | 5,054 | ..... | 87.6 |
| | 467,392 | 451,347 | 5,943 | 3,862 | 6,144 | 8.7 | 87.6 |

[1] Phelps, Dodge & Co. Ann. Rept. for year ending Dec. 31, 1916.

In addition to the above ores from producing mines there were 2,345 tons of tribute ore, 266 tons from the Gem mine, at Santa Rosa, 497 tons from the Standard, and 83 tons from the Manganese Blue.

From the Arizona Copper Co.'s report for the fiscal year[1] the following statements are taken:

During the year our production of copper amounted to 34,144,840 pounds, which compared with 37,416,010 pounds for the previous year.

The total ores mined from the company's properties amounted to 905,486 tons, and the yield as indicated by the smelter returns from ores treated was 36.06 pounds of copper per ton of ore, which compares with a yield of 39.23 pounds per ton treated during the previous year.

The period under review opened under very unfavorable circumstances, the entire operations of the company and those of the two other large producers in the district being at a standstill on account of a strike brought about by the entrance into the district of the Western Federation of Miners, the recognition of which was refused by the companies. * * *

The mines reopened during the last days of January, but the smelter did not begin producing copper until the middle of February, hence the period during which the property was in active operation was only seven and one-half months.

The Shannon property[2] remained closed on account of the labor strike of 1915 during January, 1916, and produced in 11 months' operation 9,364,968 pounds of copper, 1,327.5 ounces of gold, and 62,935 ounces of silver. The average cost per pound of copper was 18.461 cents, and the average selling price 27.244 cents per pound. This company owns and operates the Shannon Railway between its mines and smelter. Construction of the new leaching plant was hampered by delays in the delivery of material and machinery, but the management plans to have it in operation in April, 1917. A dividend of $150,000 was paid during the year, and $671,054.70 was transferred to the surplus.

## MARICOPA COUNTY.

Twenty-two producers reported the output of 18,671 tons of ore in 1916, which was 12,452 tons less than was reported by the same number of producers in 1915. The total average value per ton decreased from $9.63 in 1915 to $3.82 in 1916, and the gold and silver value of this ore from $9.09 to $3. The milling ores aggregated 764 tons and produced gold and silver bullion and lead concentrates containing a small quantity of copper with good percentages in gold and a little silver. Only 237 tons of ore of smelting grade were shipped from the county. The total value of all of the ore milled and shipped amounted to $71,259, a decrease of $230,606 from 1915. The reports of three placer operators show the recovery of $412 in gold and 2 ounces of silver, against an output of $998 in gold and 6 ounces of silver in 1915.

*Agua Fria district.*—Very little activity was reported in the district during 1916, and only a small quantity of bullion was reported.

*Cave Creek district.*—The Burris prospect—Mormon Girl—and three other properties were reported to have mined or milled ore valued at $5.461 in gold, silver, and copper. The first mentioned was the principal producer of copper ore.

*Sunset district.*—Some ore of milling grade, containing gold and silver, yielded bullion from one property, and a small quantity of

[1] Arizona Copper Co. Ann. Rept. for year ending Sept. 30, 1916.
[2] Shannon Copper Co. Ann. Rept. for year ending Dec. 31, 1916.

lead and copper ore was shipped from three other prospects in the district. The Sunset Road mine yielded a small quantity of gold ore, which was shipped directly to the smelter.

*Vulture district.*—The Vulture mine produced bullion containing gold and silver, and concentrate, which was shipped with smelting ore and yielded some copper and lead in addition to the gold and silver. There were also two prospects from which shipments of copper and lead ore were made.

*White Picacho district.*—The Orion group of claims was worked in 1916 and yielded a small quantity of lead ore containing silver.

## MOHAVE COUNTY.

*Mine production in Mohave County, Ariz., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 35 | 227,435 | $1,626,437 | 287,214 | 998,671 | 6,459,557 | 17,382,849 | $4,405,894 |
| 1916 | 45 | 207,536 | 1,038,814 | 270,193 | 1,270,051 | 5,849,842 | 17,047,117 | 4,216,987 |
| Increase or decrease, 1916 | | −19,899 | −587,623 | −17,021 | +271,380 | −609,715 | −335,732 | −188,907 |

The total average value per ton of this ore increased from $19.37 in 1915 to $20.32 in 1916, and the gold and silver value decreased from $7.79 to $5.86. The total gold decreased from $1,626,437 in 1915 to $1,038,814 in 1916. The value of the silver increased from $145,618 in 1915 to $177,787 in 1916; that of copper, from $174,767 to $312,433; that of lead, from $303,599 to $403,639; and that of zinc, from $2,155,473 to $2,284,314. Most of the ore produced in the county is of milling grade and yields bullion or concentrates. There were 97,143 tons of ore treated by amalgamation or cyanidation, which produced $907,983 in gold and 25,079 ounces of silver, with a total value of $924,485, or an average value per ton of $9.52. The concentrating ores aggregated 100,363 tons and produced 34,086 tons of concentrates, against 69,207 tons of ore and 34,188 tons of concentrates in 1915. The concentrates in 1916 contained $119,057 in gold, 219,672 ounces of silver, 172,500 pounds of copper, 5,664,698 pounds of lead, and 16,604,590 pounds of zinc, having a total value of $2,921,915, or an average value per ton of $85.72. Crude ore shipped to smelters amounted to 5,400 tons, against 7,294 tons in 1915. In 1916 shipping ore contained $6,662 in gold, 25,253 ounces of silver, 1,097,551 pounds of copper, 185,144 pounds of lead, and 442,527 pounds of zinc, and had a total value of $365,350, or an average value per ton of $67.66.

*Aubrey district.*—The Santa Rita claim, situated 30 miles south of Yucca, on the Santa Fe Railway, yielded some copper ore of shipping grade containing gold and a little silver.

*Bentley district.*—Five producers reported the output of 3,797 tons of copper ore of shipping grade. Included in this output was one lot of zinc ore. The output of the district was valued at $265,820. The principal producers were the Grand Gulch and Savanic proper-

ties. The Bonney & Minnie copper claims, situated in the Grand Canyon, were also producers of copper ore containing a little silver. Included in the total was the output of rich copper ore, containing silver, from the Copper Mountain property situated some distance east of the district.

*Cedar Valley district.*—Considerable activity was in evidence in the district, and especially at the Arizona Southwestern and Diamond Joe properties. In addition, a large quantity of molybdenum ore was produced from the Leviathan property. There were 1,141 tons of ore produced containing $508 in gold, 3,118 ounces of silver, 13,320 pounds of copper, and 14,487 pounds of lead, valued in all at $6,836, or an average value per ton of $5.99.

*Chemehuevis district.*—The Dutch Flat property, equipped with a 1-stamp mill to treat ore by amalgamation and concentration, produced a small quantity of bullion and lead concentrate containing gold and silver.

*Cottonwood district.*—The Walkover property was operated for a time by lessees, and about 600 tons of ore said to have been treated, from which gold bullion was extracted. The Copper Giant property, a producer of copper ore in 1915, was under development.

*Greenwood district.*—The Bland claim produced a small tonnage of gold ore, which yielded bullion by treatment in an amalgamation mill.

*Hackberry district.*—The Lucknow & Music Mountain and the Hackberry properties were operated during the year, the former producing gold and silver bullion in its 50-ton Chile mill equipped for amalgamation, concentration, and cyanidation of the ore. The Hackberry mine yielded silver ore containing lead and a little gold and copper.

*Maynard district.*—A test shipment of silver ore was made from the Silver Bell property.

*San Francisco district.*—This district produced 94,615 tons of ore and 630 tons of tailings, yielding bullion containing $892,681 in gold and 23,812 ounces of silver, valued in all at $908,349, or an average value per ton of $9.54. The principal properties producing were the Tom Reed and the Gold Road, mining almost equal quantities of gold ore treated by cyanidation. These two outputs constituted the larger part of the district production in 1916.

At the Gold Road mine[1] the ore in the lower levels proved to be of low grade. The cost of mining, due to general increase in wages and cost of material and the natural condition of the mine, showed that the ore could not be mined with profit. Operations at depth were, therefore, suspended. Instead, exploration work was undertaken from the upper workings. The results have been encouraging, a new ore chute of good grade having been found, which is located so that it can be mined at reasonable cost. Milling operations were suspended toward the end of 1916.

The Tom Reed mine,[2] according to the annual report of the company, yielded at its cyanidation plant gold bullion valued at $486,677.98, from 46,170 tons of ore, for the year ending March 31, 1917. For the previous year 29,916 tons of ore were milled, yielding $661,-

[1] United States Smelting, Refining & Mining Co. Eleventh Ann. Rept., for year ending Dec. 31, 1916.
[2] Tom Reed Gold Mines Co. Ninth Ann. Rept., for year ending Apr. 1, 1917.

870.68. Altogether the mine has produced since the beginning of operations to April 1, 1917, bullion valued at $6,320,380.15. No dividends were reported in 1916. The following extract is taken from the company's annual report:

Ten stamps were operated from April 1, 1916, to June 19, 1916. Owing to the increased tonnage produced in the Ben Harrison workings, and in order to handle the same, five more stamps were put in operation on this date. One week later, June 26, 1916, it was found necessary to operate the remaining five stamps. The full 20 stamps have operated continuously since that date.

46,170 tons of ore were treated during the year, an average of 76.86 tons per day for the first three months, and an average of 142.93 tons per day for the last nine months, giving an average of 126.48 tons per day for the year. Average value of ore treated was $11.03; tailings loss, 35 cents; final extraction, 97.61 per cent. 43,519 tons of this ore was produced from the Ben Harrison workings, 2,026 tons from the Aztec, and 625 tons tailing scrapings. (Average value of scrapings, $14.86.) * * *

In December, 1916, orders were received to make estimates and draw up plans for the enlargement of the mill to 300 tons per day capacity. * * * The new mill unit consists of the following equipment: One 6 by 5 foot Allis-Chalmers ball mill (coarse grinder); two 5 by 6 foot Allis-Chalmers ball mills (fine grinder); three Dorr duplex classifiers; one 40 by 12 foot redwood tank, equipped with Dorr thickener machinery; four 40 by 12 foot redwood tanks, equipped with Dorr agitator machinery; one 300-ton Merrill zinc precipitation press complete.

Among the new properties that are attracting attention is the United Eastern, which adjoins the Tom Reed mine on the northwest, and is often referred to as the "Bonanza." It is but a year and a half old and is reported to have in sight, according to the estimates of mining engineers, $11,000,000 in gold-silver ore, averaging $26 per ton. The mine contains more than 2,000 feet of drifts and has good ore bodies on all levels between the depth of 300 and 700 feet. The vein is reported to be 43 feet wide on the 555-foot and 665-foot levels, and the entire width is pay milling ore. Of this width 30 feet, proved for the distance of 650 feet, averages $40 per ton and carries considerable free gold. In the latter part of 1915 shipments of $30 ore removed during development were made to the Gold Road mill, but in 1916 the ore was held for the new mill. A new 200-ton cyaniding plant, in which gyratory crushers and ball mills will be used instead of stamps, was completed at the mine late in December, 1916. Several other new properties similar to the United Eastern are being developed and in some of them good ore is found at depths of from 200 to 500 feet. For a fuller discussion of the geology of the district and its new developments, the reader is referred to a paper by F. C. Schrader, of the United States Geological Survey.[1]

The Gold Dust Co. erected a small mill, and a number of other companies in the district discovered ore and made a few shipments to the Gold Road mill.

In the Secret Pass section, the Orphan claim produced a small quantity of gold and silver bullion recovered in a 2-stamp amalgamation mill.

*Wallapai district.*—Twenty-one producers reported 104,658 tons of ore containing $126,241 in gold, 229,237 ounces of silver, 190,807 pounds of copper, 5,825,791 pounds of lead, and 17,024,626 pounds of recoverable zinc, valued in all at $3,007,298, or an average total

[1] Am. Inst. Min. Eng. Bull. 119, pp. 1935–1967, November, 1916.

value per ton of $28.73. Of this ore, the largest quantity, or 99,292 tons, was concentrated and yielded 34,064 tons of concentrate containing gold, silver, copper, lead, and zinc. This concentrate, with 1,286 tons of ore containing the same metals, was shipped directly to the smelter. There were also 4,000 tons of old tailings reconcentrated whose product was contained in the concentrates shipped. In addition to this output, there were 80 tons of ore treated at gold and silver mills. The principal producer was the Golconda mine, from which zinc concentrate containing lead, copper, gold, and silver was produced. Next in importance was the output of the Tennessee mine, which yielded both a lead and a zinc product by concentration at Needles, Cal. Production of ore was also reported from the operations of the Banner mine, situated on Stockton Hill. The property is equipped with a 150-ton concentration plant, in which the ore and some old tailings were milled and yielded principally lead concentrate and a small quantity of lead-zinc concentrate, each of the products carrying good values in silver and gold and also a little copper. Among the other producers were the Middle Golconda, Schulkill, Silver Hill, Rainbow, and Kingman Zinc.

A description of the Golconda mine and mill appeared in a recent publication[1] as follows:

The ore in the main Golconda vein is confined to a high-grade streak averaging 18 inches thick but varying from a few inches to 6 feet or more in lenticular shapes. On both the foot and the hanging wall is soft waste that mixes with the ore mined, thus making a milling ore averaging about 16 per cent zinc. This metal is present as blackjack with iron in the combined form, therefore not susceptible to mechanical separation one from the other.

About 150 tons per day is stoped from the 1,000 and 1,100 foot levels and hoisted through the main shaft, which is an incline on the Golconda vein. At present the development is confined to the 900, 1,000, 1,100, and 1,200 foot levels; sinking will be resumed when the station is completed on the 1,200-foot. Ventilation is afforded by the natural passage of fresh air through the Prosperity adit, which is north of the main shaft at the 600-foot level, thence, through the lower workings, and out through the Tub shaft near the south end of the mine.

The concentrator, situated immediately below the shaft, at present consists of two parts, a crushing and a coarse concentrating plant, being the old Golconda mill with jigs and tables, and a fine concentrating plant, which treats the tailing from the old mill together with enough from a tailing dump, containing 5½ per cent zinc, to make a feed of 200 tons per day for the tube mills that operate in closed circuit with Dorr classifiers, thence delivering the pulp to Callow flotation cells. Plans are under way, but not yet consummated, for making changes throughout the concentrator. The machines best adapted for the treatment of the ore are being determined by experiment. It has, however, already been decided to replace the tube mills with Marcy mills. Water is carefully conserved. From 1,200 to 1,500 tons of concentrate is produced each month, containing about 42 per cent zinc, 9 per cent iron, 1 per cent lead, with some silver and gold. The total extraction is 87 per cent. The concentrate is delivered by automobile truck to the railroad about 5 miles distant. During 1916 the production was 11,000,000 pounds of zinc, 80,000 ounces silver, and 5,000 ounces gold.

No changes were made in the operation of the Needles plant,[2] with the exception of an addition to the flotation unit in order to improve recoveries and the grade of the product. The mill treated 47,570 tons of ore during 1916, practically all of which originated at the

[1] Mason, R. T., Mining in northwestern Arizona: Min. and Sci. Press, May 5, 1917, p. 627.

[2] United States Smelting, Refining & Mining Co. Eleventh Ann. Rept., for year ending Dec. 31, 1916.

Tennessee mine, at Chloride, operated under lease and bond. The ore is a complex lead, zinc, iron sulphide containing gold and silver. The cost of mining, transportation, and milling is high, but with the prevailing prices of metals the ore leaves a satisfactory profit and the operations during the past year have been very successful.

The Tennessee mine[1] is operated through a vertical shaft to the 1,400-foot level and a winze from the 1,400 to the 1,600 foot level, where driving is in progress. About 150 tons of ore, containing 15 to 16 per cent of zinc, 6 to 8 per cent of lead, 28 per cent of iron, and $7 in gold and silver, was hoisted daily from the stopes above the 1,400-foot level. The vein dips from 78° to 80° E., except between the 900 and the 1,200 foot levels, where it turns over to 75° W. The ore lies betwen schist and pegmatite and is always associated with the latter rock. It assumes lenticular forms, usually one ore body being directly above another and sometimes separated by only a few feet of gouge. Square sets are employed, the stopes being filled as the work progresses, and spiling is frequently needed. The cost for timbering is 78 cents per ton. Wages for underground work range from $4 to $6; contracts are let on development work; and the bonus system is used in all cases. The ore is shipped by way of the Santa Fe Railway to the concentrator at Needles. The zinc in the Tennessee ore occurs both as blackjack and as the resinous variety of blende. On account of excessive sliming the tailing formerly contained 8 per cent of zinc, but this has since been reduced to 2.5 per cent of zinc by the introduction of flotation. The tailing now contains about 0.1 ounce of gold, 0.6 ounce of silver, 0.1 per cent of lead, 2.5 per cent of zinc, 5.7 per cent of iron, and 77 per cent of silica.

## PIMA COUNTY.

Sixty-two operators produced 173,985 tons of ore in 1916, against 35,394 tons and 49 producers in 1915. The output of these deep mines in 1916 included $3,132 in gold, 176,894 ounces of silver, 13,110,557 pounds of copper, 1,058,145 pounds of lead, and 126,250 pounds of zinc, valued in all at $3,434,654, or an average value per ton of $19.74. The placer output was $1,773 in gold and 40 ounces of silver. Nearly all of the ore produced was of shipping grade, only 5 tons being treated at a gold and silver mill and 1,076 tons concentrated.

*Ajo district.*—The Tucson, Cornelia & Gila Bend Railroad, consisting of 43.5 miles of standard-gage track, was constructed from Gila Bend to Ajo for the purpose of affording rail transportation for the operation of the New Cornelia Copper Co.

The construction of the 5,000-ton copper leaching plant[2] of the New Cornelia Copper Co. progressed rapidly during 1916. It is expected to be ready in June, 1917, to produce approximately 100,000 pounds of electrolytic copper a day. Shipments of siliceous copper ore were made daily to the Calumet & Arizona smelter at Douglas in 1916.

*Amole district.*—The Old Yuma property was operated after a long period of idleness, producing ores which were concentrated.

[1] Mason, R. T., Mining in northwestern Arizona: Min. and Sci. Press, May 5, 1917, p. 627.
[2] Calumet & Arizona Mining Co. Ann. Rept. for year ending Dec. 31, 1916.

Several cars of lead concentrate were shipped to El Paso and a few cars of wulfenite were shipped east as a molybdenum product. There were several smaller shipments of copper ore and of lead ore carrying silver from the district.

*Baboquivari district.*—From the Papago Chief property some copper ore containing silver and a little gold was shipped to Douglas, Ariz. The property has a vertical shaft 50 feet deep and 6,000 feet of drifts.

*Empire district.*—Copper-lead ore, containing silver, was shipped from the Copper Point & Verde Queen, Jerome No. 2, and State of Maine properties in 1916.

*Gunsight district.*—From the Victoria property a few tons of lead ore, containing silver and a little gold and copper, was shipped to the smelter in 1916.

*Helvetia district.*—Eleven producers reported the output of 14,609 tons of ore mined and shipped directly to the smelters, and containing $289 in gold, 19,300 ounces of silver, 1,958,825 pounds of copper, and 71,903 pounds of lead, valued in all at $499,820, or an average value per ton of $34.21. The principal production came from the Narragansett; other productions reported were from the Copper World, Rosemont, Sweet Bye and Bye, Bulldozer, and Peach properties.

*Coyote district.*—From the Bonanza group copper ore carrying gold and silver was shipped in 1916.

*Pima district.*—Nineteen producers reported the shipment of 76,043 tons of ore, containing $270 in gold, 100,439 ounces of silver, 6,683,094 pounds of copper, 544,877 pounds of lead, and 84,650 pounds of recoverable zinc, valued in all at $1,759,340, or an average value per ton of $23.14. All of this ore, with the exception of 136 tons which was of milling grade, was shipped directly to the smelters. The greatest part of the copper ore shipped was from the Azurite property, operated by the Mineral Hill Co. Other producers were the Bush & Baxter, Morgan, Vulcan, Plumed Knight, and Glance properties. The San Xavier yielded some oxidized zinc ore containing silver.

*Quijotoa district.*—One car of concentrate containing copper was shipped from the district in 1916. There was also shipped a small quantity of lead ore containing a little silver and a trace of copper.

*Santa Catalina district.*—From the Pontotoc mine copper ore containing silver was shipped to El Paso. This property is opened by a shaft 135 feet deep and has 250 feet of drifts.

*Santa Rosa district.*—One lot of copper ore was reported to have been shipped from the Blue Jay property. This district is said to be situated west of the Silver Bell district.

*Silver Bell district.*—Ore of smelting grade was treated largely at the Sasco smelter, which began operations in 1916 and treated custom ores from the district and from various parts of Arizona. Eight producers in this district yielded 74,499 tons of copper ore containing gold, silver, and copper. There were also 535 tons of lead ore shipped to El Paso, and a few tons of zinc ore were shipped from the Atlas mine to an eastern refinery. The Imperial Copper mine was the largest producer of copper. There were shipments of similar ore made from the Red Rock and Crepin properties. Lead

ore containing silver and a little copper was reported from the Carbonate group.

The Imperial mine at Silver Bell and the Sasco smelter were operated in 1916 under the management of the American Smelting & Refining Co. At the same time the Arizona Southern Railroad was put in running condition between Red Rock and Silver Bell.

### PINAL COUNTY.

Forty-five operators produced 3,464,007 tons of ore, the principal part of which was the output of one producer. The ore output was greater by 535,368 tons than the production of 46 operators in 1915. The total average value per ton increased from $4.14 in 1915 to $6.28 in 1916, and the gold and silver in this ore from 9 cents to 15 cents a ton. Nearly all of the ore, or 3,409,582 tons, was of concentrating grade, and produced 210,180 tons of concentrate, most of which contained copper, there being only a small quantity of lead concentrates, which were recovered from one property. The ores of smelting grade, shipped directly to smelters, aggregated 53,746 tons and contained 1,042.76 ounces of gold, 205,962 ounces of silver, 7,445,090 pounds of copper, 92,539 pounds of lead, and 19,826 pounds of zinc, valued in all at $1,997,613, or an average value per ton of $37.17. In 1915 the shipments of ore aggregated 17,057 tons, valued at $600,216, or an average value per ton of $35.19. At gold and silver mills 679 tons of ore were treated and produced 322.76 ounces of gold and 324 ounces of silver. Placer bullion was recovered amounting to $224 in gold and 2 ounces of silver, against an output valued at $606 in gold and 3 ounces of silver in 1915.

*Bunker Hill district.*—Copper ore from the Jewel & Hognason property was produced and shipped directly to the smelter. There was also a small output of copper and lead sulphide ore shipped from the Eureka property.

*Casa Grande district.*—There were 14 producers reporting the output of 1,684 tons of ore. The larger part (1,049 tons) was of shipping grade, and 610 tons yielded lead concentrate, all of which, with 25 tons of ore treated in a gold and silver mill, was valued at $50,226. The principal producers of copper were the Copperosity, Lake Shore, Reward, Carmen, and House properties. There were also shipments made of copper ore and some lead ore from the Andrada property. From the Vekol property some lead ore containing silver was reported to have been shipped.

*Goldfields district.*—The Young Mines Co. was a producer of bullion recovered from a gold ore which was amalgamated.

*Mineral Creek or Ray district.*—Nearly all the district ore output was from the Ray mine, with smaller quantities from the Ray Arizona and the Arizona Hercules. A flotation plant was in course of construction at the Arizona Hercules.

The Ray mines[1] were purchased 10 years ago by the present company from English owners who had failed to operate them successfully. There were then approximately 600,000 tons of ore in sight. There have since been developed by drill prospecting 106,667,080 tons of ore, and 13,293,854 tons have been extracted and concen-

[1] Ray Consolidated Copper Co. Eighth Ann. Rept., for year ending Dec. 31, 1916.

trated. During these 10 years the company expended for development, construction, and equipment upon its properties, a total of $13,800,513.54. Of this amount, $6,908,448 came from the sale of capital securities and the balance of $6,892,065.54 came from the earnings from operations. The amount earned in 10 years was $25,501,974.11. Total dividends of $8,931,100.12 have been paid to stockholders, and the balance of $13,813,177.68 has been added to earned surplus. The annual report of the company continues with the following paragraphs:

The total amount of ore mined from all sources during the year and shipped to the reduction works at Hayden was 3,363,466 tons, an average of 9,190 tons per day, containing 1.63 per cent copper. For the year 1915 the total production was 2,863,517 tons, or an average of 7,845 tons per day. Of the ore received at the mills for 1916, 32,235 tons, averaging 4.147 per cent copper, was sorted or selected ore which was diverted to the smelter for direct smelting. The remainder, amounting to 3,331,231 tons, equivalent to 9,102 tons per day, and averaging 1.607 per cent copper, was milling ore. * * *

The slight decrease in copper contents of the ore mined during the year, as compared to the previous year, was caused largely by the rapid drawing of the last ore in some large medium-grade reserve blocks. This was necessary in order to maintain, and, in fact, increase tonnage, and was due in great measure to the enforced curtailment of production and almost complete suspension of development and stope preparation for nearly a year beginning with the month of August, 1914. It has been repeatedly stated in previous reports that the areas and zones in which the principal mining operations have been conducted in the past are shown by development records to be of considerably lower grade than the average for the entire deposit. * * *

The mining costs for the year were 80.073 cents per ton, of which 5.146 cents per ton was due to coarse crushing and loading, leaving the net mining cost 74.927 cents per ton.

The high-grade ore body developed through and adjacent to the No. 3 shaft is, as has been frequently stated, of a character not adapted to the application of the regular system of mining used. The so-called square set system is applied here, requiring heavy timbers and close filling. As a result of this the per ton cost of mining this ore body is approximately four times as great as that of mining the larger bodies of average grade. These high costs are included in the average mining costs stated above. If the tonnage produced from the No. 3 shaft and the cost of producing it were eliminated from the general figures, the average mining cost for the year, excluding coarse crushing and loading costs, would become 69.12 cents. The higher mining costs for the year 1916 are entirely due to an increase of about 30 per cent in the cost of labor and supplies as compared to normal rates. * * *

The average grade of the ore milled for 1916 was 1.607 per cent copper and the average recovery for the year was 70.20 per cent of the entire copper contents, equivalent to 22.56 pounds of copper per ton, as compared with 64.11 per cent, or 21.45 pounds of copper per ton, for the previous year. This increase in recovery is the direct result of additions and improvements in mill equipment made during the year. The concentrate production for the year was 188,778 tons, containing an average of 19.914 per cent copper. * * *

The cost of milling for the year was 55.35 cents per ton, as compared with 50.86 cents for the previous year. * * *

In addition to the copper in concentrates, there was contained in ores shipped direct to the smelter a total of 2,673,798 pounds, making the gross production of copper from all sources 77,856,713 pounds.

The average cost per pound of net copper produced from milling ores, after making allowances for smelting and refining deductions and crediting dividends from the Ray & Gila Valley Railroad and other miscellaneous income as a reduction of operation costs, was 10.134 cents per pound. The combined cost per pound of net copper produced from milling ore and direct shipping ore for the year was 10.267 cents, as compared with 9.423 cents per pound for the previous year. These costs include all operating and general charges, except Federal income tax, as well as 12½ cents per ton of ore milled, which is applied to the retirement of mine-development costs.

*Old Hat district.*—Six producers reported the output of 177 tons of ore, 50 tons of which was treated at gold and silver mills and yielded bullion, and 127 tons were shipped directly to the smelters. The total output of the district contained $1,056 in gold, 711 ounces of silver, and 26,147 pounds of copper, valued in all at $7,957. The most important producer was the Mammoth Collins property, where the re-treatment of tailings took place, recovering molybdenum concentrate with some values in gold contained in the concentrate. Production was also reported from the Daily Arizona, Armour, Stratton, and Tip Top properties.

*Pioneer district.*—Ten producers reported the output of 89,770 tons of ore, of which 76,632 tons were concentrated and yielded 21,341 tons of concentrate containing gold, silver, copper, lead, and zinc, and 13,136 tons of crude ore containing the same metals were shipped directly to smelters. The total output was valued at $2,706,442. All the producers, with the exception of the Magma mine, reported the shipments of small quantities of ore.

According to the annual printed report of the company[1] operating the Magma mine, 83,743 tons of copper ore averaging 5,696 per cent of copper and 6.376 ounces of silver were mined and treated. This included 9,126 tons of copper ore, averaging 16.756 per cent of copper and 18.802 ounces of silver and $1.76 in gold per ton. The mill ore, also included in the total tonnage mined, was 74,617 tons, averaging 4.344 per cent of copper and 4.854 ounces of silver per ton. From the milling ore 20,855 tons of concentrate was obtained, averaging 12.920 per cent of copper and 14.251 ounces of silver and $2.17 in gold per ton. In addition there was an output of 3,450 tons of carbonate ore, assaying 7.936 per cent of copper and 5.611 ounces of silver and $1.10 in gold per ton. Lead concentrate—183 tons—contained 1.070 per cent copper, and 24,350 ounces silver and 43 cents in gold per ton, 15.10 per cent of lead, and 16.97 per cent of zinc. Zinc concentrate, 429 tons, assayed, per ton, 32.440 ounces of silver and 25 cents in gold and 7 per cent of lead and 38.27 per cent of zinc. The annual report of the company continues as follows:

> An additional lead-zinc section, with a capacity of 50 tons per day, was added to the mill. This section was successfully used in treating lead-zinc ores for three months, when it was decided it was advisable to change the section over to a copper-ore section in order to treat a larger tonnage of copper ore. This was done during the month of November with very few alterations. This new section is now treating 100 tons of copper ores per day, with an extraction equally as good as that of the old section.
>
> All stoping of ore for the year was done above the 1,300-foot level. Work below this level was restricted to development. During the year 93,808 tons of ore were mined, of which 23.6 per cent came from development work and 76.4 per cent came from stopes. At the end of the year 184,765 tons of ore had been mined since the commencement of operations, of which 30.7 per cent came from development work and 69.3 per cent came from stopes. * * *
>
> The average assay of mill tailings was 0.7158 per cent copper (of which 0.225 per cent copper was oxidized) and 0.84 ounces of silver per ton. Sorting and milling the copper sulphide ores resulted in an extraction of 83.13 per cent of the total copper in the mill heads and 88.54 per cent of the total copper in the mine-run ore treated by hand sorting and milling.
>
> The net production of copper after deducting all smelting and refining losses was 8,473,580 pounds. The net value of gold and silver contents of the copper product was $375,885.38, and the net value of lead and zinc product was $24,491.78. * * * On the 8,473,580 pounds of copper produced during the

[1] Magma Copper Co. Ann. Rept. for year ending Dec. 31, 1916.

year, after crediting gold, silver, zinc, and lead values, there was a profit made of 13.919 cents per pound. The total operating profit was $1,179,508.14. The average selling price of copper was 24.722 cents per pound, and the average cost of producing copper was 10.803 cents per pound.

The higher cost of labor and supplies and the heavy ground requiring close timbering materially increased the cost of mining operations during the year.

*Riverside district.*—Two producers of copper ore reported a small output in 1916. The principal production came from the Kelvin Sultana property.

### SANTA CRUZ COUNTY.

Thirty-four producers reported 30,387 tons of ore in 1916, or 16,027 tons more than was reported by 27 producers in 1915. The total value of this ore, containing gold, silver, copper, lead, and zinc, was $854,605 in 1916, against $292,514 in 1915. In 1916 the ore sold and treated contained $6,588 in gold, 69,731 ounces of silver, 2,124,589 pounds of copper, 1,157,983 pounds of lead, and 1,489,435 pounds of zinc, valued, in all, at $854,605, or an average value per ton of $28.12. Ore of shipping grade amounted to 12,926 tons and contained most of the copper and some of the lead. The ores produced were classified as copper-zinc ore, 11,280 tons; copper ore, 9,996 tons; lead ore, 6,598 tons; zinc ore, 1,808 tons; copper-lead ore, 457 tons; and siliceous ore, 248 tons.

*Harshaw district.*—Reports received from six producers gave a production of 6,378 tons of ore, containing $414 in gold, 10,660 ounces of silver, 46,375 pounds of copper, and 788,543 pounds of lead, valued, in all, at $73,245, or an average value per ton of $11.48. The larger part of the ore (5,992 tons) was milled and yielded 1,712 tons of lead concentrate containing a little copper, gold, and silver. Shipping ore forwarded directly to the smelters amounted to 386 tons containing the same metals. The principal production came from the Flux and the Hardshell properties worked by lessees during 1916. There were also shipments made from the Basin, Eldorado, and Andes & Aztec properties.

*Nogales district.*—Shipments of copper ore containing a little lead and some gold and silver were made from three properties in the district. The production was indirectly reported.

*Oro Blanco district.*—The Austerlitz property, yielding gold ore, and two other properties, were the only producers in the district. There was one small shipment of copper ore.

*Palmetto district.*—Copper ore was shipped from the Three R. property, which is opened by a shaft 600 feet deep and has 5,500 feet of drifts, with an adit 1,100 feet long. During 1916 a 100-ton flotation mill was erected and was reported in operation early in 1917.

*Patagonia district.*—Ore shipped and milled by six producers aggregated 17,340 tons, containing $1,494 in gold, 46,036 ounces of silver, 1,244,774 pounds of copper, 175,807 pounds of lead, and 1,489,435 pounds of recoverable zinc, valued in all at $549,715, or an average value per ton of $31.70. The principal part of the ore produced was concentrated at the Duquesne mine and yielded zinc and copper concentrate. There were also shipments of crude copper ore and zinc ore directly to the smelter. The Gladstone and the Independent mines were also producers.

*Red Rock district.*—The Hummer and the Frisco claims were worked during the year and produced a small quantity of lead and copper ore.

*Tyndall district.*—Six producers reported the production of 413 tons of ore of shipping grade, containing $227 in gold, 3,699 ounces of silver, 30,962 pounds of copper, and 104,268 pounds of lead, valued in all at $17,473. The principal producer was the Bonanza property, which shipped copper-lead ore containing silver. There was also a production from the Royal Blue property and smaller shipments from the Clove and Cobre properties.

*Wrightson district.*—Shipping ore amounting to 379 tons, reported by six producers, contained $304 in gold, 2,791 ounces of silver, 14,563 pounds of copper, and 85,007 pounds of lead, valued in all at $11,588, or an average value per ton of $30.58. The Dixie, Pinal, Blue Lead, American Boy, and Lee properties were producers.

## YAVAPAI COUNTY.

*Mine production in Yavapai County, Ariz., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.a | Silver.a | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 107 | 614,843 | $791,884 | 1,343,363 | 59,229,103 | 161,750 | 48,580 | $11,851,688 |
| 1916 | 95 | 967,558 | 1,035,351 | 1,735,302 | 109,525,718 | 265,023 | 583,741 | 29,217,015 |
| Increase, 1916 | ..... | 352,715 | 243,467 | 391,939 | 50,296,615 | 103,273 | 535,161 | 17,365,327 |

a Includes placer production.

Reports received from 88 deep mines and 7 placers gave a total metal output in 1916 whose value was $17,365,327 greater than the value of the output reported in 1915 by 107 operators of deep mines and placers. The total average value per ton of the ore increased from $19.25 in 1915 to $30.19 in 1916, and the gold and silver value in this ore decreased from $2.37 to $2.25. Of the total value of the metals reported, $1,035,351 was for gold, $1,141,829 was for silver, $26,943,327 was for copper, $18,287 for lead, and $78,221 for zinc. Compared with that of 1915 the output of each metal shows a substantial increase. Ores of smelting grade shipped to various smelters aggregated 820,713 tons. Nearly all of this first-class ore was copper ore (819,222 tons), of which much the larger part was sulphide ore (801,123 tons), and the remainder copper oxidized ore (18,099 tons). The total value of the smelting ores was $27,493,285, or an average value per ton of $32.28. There were produced 43,733 tons of dry or siliceous ore, the larger part of which was treated at gold and silver mills. Concentrates, amounting to 17,842 tons, derived from 96,042 tons of ore, were also smelted, and contained $89,074 in gold, 95,504 ounces of silver, 3,670,756 pounds of copper, 29,748 pounds of lead, and 537,768 pounds of zinc, valued in all at $1,129,035, or an average value per ton of $63.28. The placer output amounted to $3,580 in gold and 44 ounces of silver, as against a production of $13,910 in gold and 133 ounces of silver in 1915.

*Agua Fria district.*—The Binghampton property, which is opened by a vertical shaft 600 feet deep and an adit 600 feet long, was actively operated, beginning July 20. The 100-ton flotation mill near the property treated the ore and produced copper concentrate carrying a little silver and some gold. The Gold Dot and Copper Queen properties were also producers of copper ore which was of smelting grade.

*Big Bug district.*—Reports received of production from 18 deep mines in 1916, the same number reporting in 1915, and of bullion from placer operations, which was smaller than any previous year and amounted to only $1,672 in gold and 31 ounces of silver, indicated a total value of $1,035,460. There were 76,118 tons of ore mined, of which the greater part (52,454 tons) was milled, producing a copper concentrate, and 23,251 tons were shipped directly to the smelter. One lot of smelting ore contained zinc of commercial value. The total metallic output of the district was $71,696 in gold, 98,182 ounces of silver, 3,612,616 pounds of copper, 131,618 pounds of lead, and 10,255 pounds of zinc. From the Blue Bell property the largest quantity of ore of both milling and smelting grade was shipped to Humboldt for treatment. The Big Ledge Copper Co., operating the Braganza, Henrietta, and Butternut properties, shipped copper ore. The company will possibly rebuild the old Treadwell smelter at Mayer. Some lead ore carrying silver was produced from the property of the Arizona National Mining Co. Lessees shipped lead ore and some ore carrying zinc from the Poland property.

*Black Rock district.*—Seven producers reported the production of 114 tons of ore containing $839 in gold, 727 ounces of silver, 18,604 pounds of copper, and 332 pounds of lead, valued in all at $5,917. Sixty-nine tons of the ore were of smelting grade, and 45 tons were treated in a gold and silver mill and yielded bullion. The principal producers were the Grijalva, Big Blue, and Rich Hill properties.

*Cherry Creek district.*—Milling ore yielding bullion was produced from two properties in the district, and one shipment of copper ore was made.

*Copper Basin district.*—The Senator mine produced almost all of the output of the district, consisting of copper ore of shipping grade carrying small amounts of gold and silver. From the Copper Hill property only a small quantity of oxidized surface ore was shipped. This ore was associated with a little molybdenite, the saving of which was attempted by tests made with the oil-flotation process.

*Eureka district.*—Four properties produced 460 tons of ore containing gold and silver bullion valued at $5,470. The principal producer was the Copper Bell property, equipped with a 5-foot Chile mill. The Nieman-Crosby and Great Western properties were also producers.

*Hassayampa district.*—The reports of 16 deep-mine producers gave an output of 1,969 tons of ore, containing $12,094 in gold, 53,225 ounces of silver, 76,662 pounds of copper, 51,112 pounds of lead, and 35,718 pounds of recoverable zinc, valued in all at $74,288. The production from placer operations amounted to $275 in gold and 2 ounces of silver. The Davis, Castle, Climax, and Crook properties were the principal producers, yielding various ores, part of which was shipped to the smelter and part was treated in a milling plant.

*Humbug or Columbia district.*—Ore containing principally copper and lead was produced from the Gold Central, Golconda, and Mountain Chief properties. There was also a small production from the Kay claims.

*Peck district.*—The De Soto and Swastika properties were the principal producers. The larger part of the production was from the former property, and consisted of copper ore containing silver and gold, which was milled at Humboldt, where the concentrate was also smelted. The Swastika produced a siliceous silver ore.

*Pine Grove district.*—An old mine dump on the Saratoga property was milled and yielded bullion and concentrate carrying principally gold.

*Tiger district.*—Gold ore from the Tiger Gold property was treated and produced bullion and some concentrate carrying a little copper as well as gold and silver. The principal production of the district came from the Crown King tailings, which were re-treated by the Bradshaw Reduction Co. in its milling plant, and yielded zinc concentrate and a copper concentrate containing much iron. The operations of this company were described in a recent article[1] as follows:

> The plant of the Bradshaw Reduction Co. (formerly the Randolph-Gemmill) was successful last year (1916). Prior to last March it was run only experimentally. From then until September 26, when it was closed pending mechanical changes and an increase in capacity from 70 to 150 tons daily, the plant treated 9,300 tons of tailing from the Crown King dump. Fifty-five carloads of iron concentrate were shipped from the plant to the Humboldt smelter during that period. The concentrate carried about $18 in gold, $6 silver, and $10 copper per ton, and netted $45,000. In addition, 800 tons of zinc concentrate was shipped to smelting points in Kansas and Oklahoma, at a net profit of more than $30,000. The plant will resume operations early in March, and after treating the remaining 2,500 tons of Crown King tailing will handle ore from the Crown King, War Eagle-Gladiator, Wildflower, and other mines of the Crown King district. The properties specifically mentioned are held under lease and option by the Bradshaw Reduction Co. The Crown King is one of a number in Yavapai County and other parts of Arizona formerly worked profitably.

*Turkey Creek district.*—Only a small quantity of ore was shipped from this district in 1916. The R. and H. property was the principal producer and yielded lead-silver ore. There was also a small quantity of bullion produced.

*Verde district.*—The output of three deep mines in 1916 was valued at $26,992,986 in gold, silver, and copper. Nearly all of the ore was of smelting grade and was produced from the United Verde and the United Verde Extension properties. The latter mine added to the total copper output 36,402,972 pounds of the metal, and as it is only in its first year of production, it will, when its smelter is constructed, be an important producer in Arizona. The United Verde smelter at Clarkdale was operated steadily and produced 59,359,000 pounds of copper. The plant is reported to be treating from 2,200 to 2,500 tons of United Verde ore daily. The Copper Chief, opened by a vertical shaft 350 feet deep and by 2,000 feet of drifts, with an adit 1,200 feet long, produced gold and silver bullion from the treatment of ore in its 125-ton cyanide plant. There was also some low-grade copper ore shipped to the smelters.

The United Verde Extension Mining Co.,[2] during its first year of production, shipped directly to the smelters at Douglas and Hum-

[1] Min. and Sci. Press, Jan. 13, 1917, p. 65.
[2] United Verde Extension Mining Co. Ann. Rept. for year ending Dec. 31, 1916.

boldt 80,159 dry tons of ore, containing 2,570 ounces of gold, 128,467 ounces of silver, and 36,402,972 pounds of copper, or an average of 0.032 ounce of gold and 1.62 ounces of silver per ton and 22.70 per cent of copper. The silver and copper represent 95 per cent of the total assay content. At this writing (June, 1917) the construction of a smelting works has been commenced and is expected to be completed in 1918. Dividends paid to stockholders amounted to $1,050,000 in 1916. Development of the ore bodies and shipments, according to the annual printed report of the company, are as follows:

The ore body encountered on the 1,400 level in January, 1916, has been fully developed on that level by drifts at regular intervals, and has an area on that level of over 60,000 square feet. Between the 1,400 level and the 1,300 level this ore body has been developed by raises in the ore. Above the 1,300 level three raises have been run in the ore. At about 60 feet above the 1,300 level the oxidized zone was encountered. We do not look for any considerable amount of ore in this ore body above that point. We are certain of a large amount of high-grade ore in addition to the 700,000 tons in sight between the 1,300 and 1,400 levels. We can conservatively estimate 1,000,000 tons of 16 per cent ore in sight.

As heretofore reported a winze has been sunk 200 feet below the 1,400 level. After passing through 114 feet of 15 per cent ore and 46 feet of very low-grade ore at 160 feet it encountered one of the bars of intrusive waste characteristic of the deposit. At the bottom the winze passed out of the intrusive and encountered a chalcopyrite ore, such as is found elsewhere in the camp. The winze was stopped at the 1,600 level, and on account of the difficulty of handling the water no drifts were run from that level. * * *

*Walker district.*—The reports from six deep mines showed an output of 323 tons of ore, containing $3,653 in gold, 981 ounces of silver, 1,916 pounds of copper, and 5,381 pounds of lead, valued in all at $5,140. The placer output reported was smaller than in previous years and amounted to only $1,366 in gold and 9 ounces of silver. In 1915 the output amounted to $4,545 in gold and 42 ounces of silver. The Sheldon property was a producer of siliceous ore, lead ore, and copper ore, carrying gold with a little silver.

*Walnut Grove district.*—Six deep mines produced 312 tons of ore carrying $1,450 in gold, 1,414 ounces of silver, 3,101 pounds of copper, and 39,310 pounds of lead, valued in all at $5,855. The output of placer gold produced from one property was small. The principal producers were the McMahan group and the Vesuvius, Pioneer, and Wilson properties.

*Weaver district.*—The reports received from three deep-mine operators gave an output of 2,153 tons of ore, containing $19,102 in gold, 498 ounces of silver, 2,995 pounds of copper, and 7,616 pounds of lead, valued in all at $20,693. The principal production consisted of bullion recovered from ore mined in the Monica property and treated in a 20-stamp mill and cyanide plant. There was also a shipment of lead ore from the Old York property.

*White Picacho district.*—Two small outputs containing lead and copper were reported from the district in 1916.

## YUMA COUNTY.

Forty-five producing deep mines in Yuma County in 1916 reported 54,859 tons of ore, 25,600 tons more than was reported by 46 producers in 1915. The total average value per ton of this ore increased from $12.95 in 1915 to $21.58 in 1916, and the gold and silver value from 97 cents in 1915 to $1.25 in 1916. The total value of the

gold, silver, copper, and lead produced in the county was $1,190,362, as against an output valued at $392,894 in 1915. The placer production amounted to $6,249 in gold and 61 ounces of silver, against a recovery of $14,005 in gold and 104 ounces of silver from 13 placers in 1915. Ore of shipping grade aggregated 50,779 tons, containing 1,757.66 ounces of gold, 4,031 ounces of silver, 4,503,065 pounds of copper, and 113,695 pounds of lead. At gold and silver mills there were 4,080 tons of ore treated, which produced 1,410.18 ounces of gold and 511 ounces of silver.

*Castle Dome district.*—Ore was produced by the Big Eye, Hull, Lady Edith, Silver Dollar, and four other properties, which aggregated 218 tons having a value in gold, silver, and lead of $12,944, or an average value per ton of $59.38. The placer production reported amounted to $533 in gold and 2 ounces of silver. This was less than the production of 1915, when a placer production was reported of $1,101 in gold and 4 ounces of silver.

*Cienega district.*—Four deep-mine producers reported 2,636 tons of ore containing $19,240 in gold, 134 ounces of silver, and 309,404 pounds of copper, valued in all at $95,441, or an average value per ton of $36.21. Most of this ore came from the Empire Arizona property, which is opened by a vertical shaft 200 feet deep and by 647 feet of drifts. There is also an incline shaft of 300 feet and 534 feet of drifting. The Billie Mack and Revenue properties were also producers.

*Ellsworth district.*—The reports received from 19 deep mines showed the production of 4,988 tons of ore containing $32,833 in gold, 954 ounces of silver, 226,496 pounds of copper, and 2,675 pounds of lead, valued in all at $89,364, or an average value per ton of $17.92. The greater part of this ore, or 3,925 tons, was treated at gold and silver mills and yielded bullion. The lead and copper was contained in 1,063 tons of ore shipped directly to the smelters. The milling ore came principally from the Harqua Hala Bonanza property and was treated in a 40-stamp amalgamation mill. Among the producers of ore of shipping grade were the Critic, Desert, Detroit, Midnight, Mohawk, Waters, and Wenden Copper properties.

*Kofa district.*—The output of four deep mines consisted principally of gold bullion recovered by lessees working on old properties. One lot of shipping ore containing fine gold was made from the Independence and the Quartette properties.

*Planet district.*—All of the ore produced in the district contained copper and was of shipping grade, most of it going to Humboldt. The largest producer was the Swansea mines, operated by lessees. The smelter situated on this property was not operated.

*Plomosa district.*—There were 277 tons of gold, silver, and copper ore of shipping grade produced in the district by four properties. The output was that of the Excelsior and Shamrock mines and of several small prospects. Most of the placer gold produced was from the vicinity of Mohave Mountain, 8 miles from Quartzsite. There were three other producers reporting small quantities of gold recovered by placer operations. It is reported that there is still considerable experimental work carried on in an effort to save larger quantities of placer gold by improved methods.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN THE EASTERN STATES.

(MINES REPORT.)

By JAMES M. HILL.

## INTRODUCTION.

This section of the Mineral Resources report deals primarily with the mines of the Eastern States from which gold, silver, copper, lead, and zinc were produced in 1916. For convenience in the collection of statistics the zinc and copper mines of eastern Tennessee are grouped with the Eastern States.

Most of the mines discussed in this chapter are situated on ore deposits contained in metamorphic rocks that are of pre-Cambrian age, which have been intruded by both basic and acidic igneous rocks. This belt of rocks extends from eastern Alabama in a northeasterly direction to Canada. It is wide in northern Georgia, western South Carolina, and in central North Carolina and Virginia; but it narrows in Maryland, Pennsylvania, and New Jersey, only to open again into a broad belt in the New England States. It is bounded on the northwest by the Paleozoic rocks of the Blue Ridge and its northward continuations, and on the southeast by the sedimentary rocks of Cretaceous and younger age, which make up the Coastal Plain series. The copper, lead, and zinc deposits of eastern Kentucky and Tennessee and western Virginia are found in Paleozoic rocks, and by far the greater number are in the Knox dolomite, of Cambrian and Ordovician age. In part of the area the beds are in a nearly horizontal position, but at other places are closely folded and faulted.

The zinc deposits of northern New York are found in crystalline limestones associated with gneisses and schists, all of which are presumably of pre-Cambrian age.[1]

## MINE PRODUCTION.

The total value of the output of gold, silver, copper, lead, and zinc in the Eastern States was $45,260,289 in 1916, an increase of more

[1] Smyth, C. H., On the genesis of the pyrite deposits of St. Lawrence County: New York State Mus. Bull. 158, pp. 143-183, 1912.
Newland, D. H., Zinc ore in northern New York: Eng. and Min. Jour., pp. 1094-1095, June 9, 1906.

than 80 per cent over the production in 1915 and an increase of 296 per cent over the production in 1914. The total value is distributed among the various metals as follows: Gold, $64,370; silver, $66,012; copper, $4,207,659; lead, $109,160; zinc, $40,813,088.

As will be seen from the following table, the great increase in value is due to the increased output of the lead and zinc mines, and, of course, to the increase in value of all the metals except gold.

*Mine production of gold, silver, copper, lead, and zinc in the Appalachian States, 1915–16.*

| Year. | Ore sold or treated. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value.[a] |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 2,215,538 | $224,250 | 102,545 | 18,772,735 | 697,329 | 273,650,575 | $25,151,220 |
| 1916 | 2,241,113 | 64,370 | 100,323 | 17,104,303 | 1,582,034 | 287,889,687 | 45,260,289 |
| Increase or decrease. | +25,575 | −159,880 | −2,222 | −1,668,432 | +884,705 | +14,239,112 | +20,109,069 |

[a] The value of the production of zinc in 1915 and 1916 is not all calculated at the average zinc price used by the Survey.

## GOLD.

There were 3,113.90 fine ounces of gold produced in the Eastern States in 1916, having a total value of $64,370. Of this output the placers yielded 803.81 ounces, the siliceous gold ores 1,984.91 ounces, and copper ores 325.18 ounces, all of which showed a decrease from the production of 1915. As will be seen from the first table below, there was decrease in most of the gold-producing States, with the exception of Alabama and Virginia. This decrease in output of gold is to be explained by the apparent lack of interest in gold mining at present, due in part to increased cost of production with no increase in value of product.

## SILVER.

In 1916 there were produced in the Eastern States 100,323 fine ounces of silver, valued at $66,012. The largest production was from copper ores and the smallest from placer mines, as is shown by the second table below. In 1916 the first production of silver from lead-zinc ores was made, the output coming from ore mined in one of the New England States. There was an increase in value of silver in Alabama, New Hampshire, Vermont, Maryland, South Carolina, Tennessee, and Virginia, and a decrease in Georgia and North Carolina in 1916. Although the quantity of silver produced in the Eastern States was 2,222 ounces less in 1916 than in 1915 the value increased $14,022, owing to the increased value of silver.

*Mine production of gold and silver in the Eastern States in 1916, by States.*

| State. | Gold. | | Silver. | | Increase or decrease in value compared with 1915. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Gold. | Silver. |
| | *Fine ounces.* | | *Fine ounces.* | | | |
| Alabama | 418.44 | $8,650 | 53 | $35 | +$3,407 | +$29 |
| Georgia | 1,090.32 | 22,539 | 74 | 49 | −13,282 | −21 |
| Maryland, New Hampshire, and Vermont | | | 4,021 | 2,646 | | +2,454 |
| North Carolina | 1,269.22 | 26,237 | 663 | 436 | −145,764 | −307 |
| South Carolina | 15.48 | 320 | 28 | 18 | −3,469 | +14 |
| Tennessee | 277.63 | 5,739 | 94,701 | 62,213 | −1,123 | +11,338 |
| Virginia | 42.81 | 885 | 783 | 515 | +351 | +515 |
| | 3,113.90 | 64,370 | 100,323 | 66,012 | | |
| Increase or decrease | −7,734.19 | −159,880 | −2,222 | +14,022 | −159,880 | +14,022 |

*Mine production of gold and silver in the Eastern States in 1916, by sources, in fine ounces.*

| State. | Gold. | | | Silver. | | | |
|---|---|---|---|---|---|---|---|
| | Placers. | Dry or siliceous ores. | Copper ores. | Placers. | Dry or siliceous ores. | Copper ores. | Lead-zinc ores. |
| Alabama | 37.59 | 380.85 | | 23 | 30 | | |
| Georgia | 368.91 | 721.41 | | 35 | 39 | | |
| Maryland, New Hampshire, and Vermont | | | | | | 3,076 | 945 |
| North Carolina | 381.83 | 878.54 | 8.85 | 62 | 341 | 260 | |
| South Carolina | 15.48 | | | 28 | | | |
| Tennessee | | | 277.63 | | | 94,701 | |
| Virginia | | 4.11 | 38.70 | | 1 | 782 | |
| Total, 1916 | 803.81 | 1,984.91 | 325.18 | 148 | 411 | 98,819 | 945 |
| 1915 | 1,163.41 | 9,349.54 | 335.14 | 92 | 1,531 | 100,922 | |

## COPPER.

The production of copper in the Eastern States in 1916 was 17,104,303 pounds, valued at $4,207,659, a decrease in quantity from 1915 of 1,668,432 pounds and an increase in value of $922,430. This copper was largely derived from Tennessee ores, but some came from the copper-bearing magnetite ores of Pennsylvania, and from copper ores mined in Georgia, Maryland, North Carolina, Vermont, and Virginia. The total quantity of ore treated to produce this copper was 721,412 tons, showing an average yield of copper of approximately 1.2 per cent or about 24 pounds a ton. This low yield can be accounted for by the fact that a large part of the tonnage represents iron ores that contain little copper. Some ores shipped from Virginia are reported to have carried as much as 50 per cent of copper, and the Tennessee ores carried approximately 2 per cent of copper.

## LEAD.

The production of lead in the Eastern States in 1916 was 1,582,034 pounds, valued at $109,160. The great bulk of this production was from Virginia, but small quantities were produced in New Hampshire and Tennessee.

## ZINC.

The production of zinc in the Eastern States in 1916 was 287,889,687 pounds, valued at $40,813,088, an increase in quantity of 14,239,112 pounds over 273,650,575 pounds in 1915.[1] It will be noted that this value is more than it would be if the zinc content of the ore were calculated as spelter at 0.134 cent a pound, which was the average sales price of all grades of spelter in 1916. The difference is because of the fact that the zinc ore mined in New Jersey is not all used for the manufacture of spelter, and its value is therefore calculated on a basis which gives a combined value of the zinc oxide and of the high-grade spelter produced.

New Jersey produced more zinc than all the remaining Eastern States, and Tennessee was second with an output of nearly 53,000,000 pounds. New York and Virginia were next in rank with approximately 9,000,000 and 4,500,000 pounds, respectively. There was also a small output from New Hampshire.

## REVIEW BY STATES.

### ALABAMA.

In 1916 there were mined in Alabama 418.44 ounces of gold, valued at $8,650, and 53 ounces of silver, valued at $35, an increase of 164.81 ounces of gold and of 41 ounces of silver in 1916 over 1915. The production in 1916 came from 3 placer mines and 2 deep mines in Chilton, Cleburne, Talladega, and Tallapoosa counties, as compared with 2 placers and 1 deep mine in 1915. There were 11,063 tons of ore treated by amalgamation at the two deep mines in operation, the greater part being from Tallapoosa County.

The discovery of lead ore is reported near Jamestown, Cherokee County, and near Huntsville, Marshall County.

### GEORGIA.

In 1916 there were produced in Georgia 1,090.32 ounces of gold, valued at $22,539, 74 ounces of silver, valued at $49, and 803,699 pounds of copper, a decrease of $13,282 in the value of gold and of 64 ounces in the quantity of silver from the production in 1915, which, however, was a record year. The production of copper in 1916 was the first recovered since 1907 and was due to the reopening of some of the mines in the Ducktown district, which lie in Fannin County, Ga.

Of the output in 1916, placer mining furnished 368.91 ounces of gold and 35 ounces of silver, the remainder coming from deep mines. The deep gold mines in operation in the State treated 15,901 short tons of siliceous ore, from which 721.41 ounces of gold and 39 ounces of silver were recovered. The average value of this ore was slightly less than $1 a ton. This low value per ton was due to the development of the mining and cyanide treatment of saprolite ore bodies by T. H. Aldrich, jr., of Villa Rica. Of the ore mined the greater

[1] Revised figures.

part was treated by cyanidation, only about 1,500 tons going to amalgamation mills.

*Mine production of gold, silver, and copper in Georgia, 1915–16.*

| Year. | Number of mines. | | Ore sold or treated. | Gold.a | Silver.c | Copper. | Total value. |
|---|---|---|---|---|---|---|---|
| | Placer. | Deep. | | | | | |
| | | | *Short tons.* | | *Fine ozs.* | *Pounds.* | |
| 1915 | 31 | 9 | 20,052 | $35,821 | 138 | ..... | $35,891 |
| 1916 | 20 | 6 | 46,944 | 22,539 | 74 | 803,699 | 220,298 |
| Increase or decrease, 1916 | −11 | −3 | +26,892 | −13,282 | −64 | +803,699 | +184,407 |

a Includes placer gold and silver.

Placer mines numbering 20 were operated in Dawson, Cherokee, Forsythe, Lumpkin, Paulding, White, and Wilkes counties. Seven placers in Lumpkin County produced 135.94 ounces of gold and 5 ounces of silver. The White County placers, including the Loud mine, made nearly as much gold and considerably more silver than those of Lumpkin County.

Six deep gold mines reported production in 1916, the largest producer being the Pine Mountain mine in Douglas County, near Villa Rica, which is operated by T. H. Aldfich, jr. In Lumpkin County gold and silver were produced from deep mines on the Crown Mountain, Turkey Hill, and Standard properties. The Crown Mountain properties are under development by the Findley Ridge Mining & Power Co., which is working on the Wallace "sand vein" and in the Preacher Cut. It is reported that the ores will be concentrated and cyanided. The Royal mine in Haralson County was operated in 1916.

The Columbia mine in McDuffie County is being developed by the American Venture & Mines Corporation, which is installing a 75-ton cyanide plant.

## MAINE.

No metal production was reported from Maine in 1916. It is reported that the American Smelting & Refining Co. have reopened the old Douglas mine ,at Blue Hill, and will treat part of the siliceous chalcopyrite ore by flotation.

## MARYLAND.

The New London mine near Frederick was operated during 1916 and produced silver-bearing copper ore, and the Liberty Bell mine near Union Bridge produced some copper and silver from ore and tailings. Prospect work is still in progress near Great Falls, but the results of the work are still unknown.

## NEW HAMPSHIRE.

The Silver Lake mines in Carroll County were operated in 1916 and produced lead and zinc concentrates. None of the other metal mines in the State reported operations during that year.

## NEW JERSEY.

The production of New Jersey is, as usual, confined to the output of the Mine Hill and Stirling mines at Franklin Furnace, Sussex County. There were 712,464 tons of crude ore produced at these mines in 1916, which yielded a total of 221,396,000 pounds of zinc calculated as zinc oxide and spelter. It should be understood that only part of the zinc ore mined at Franklin Furnace is used directly for the manufacture of spelter. The greater part of this zinc is normally converted into oxide at works located in Pennsylvania.

## NEW YORK.

The Northern Ore Co., operating the Brown and White mines, near Edwards, St. Lawrence County, was the only producer in the State in 1916. A considerable quantity of zinc-bearing concentrate was made in the 200-ton mill, which began operating in March, 1915. It is reported that a 1,000-foot shaft is being sunk to develop ground which has been drilled.

The Lux Development Co., engaged in prospecting the Webb ground near Edwards, reported favorable showings.

## NORTH CAROLINA.

The gold, silver, and copper produced in North Carolina in 1916 had a value of $29,084, distributed as follows: Gold, 1,269.22 ounces, valued at $26,237; silver, 663 ounces, valued at $436; copper, 9,800 pounds, valued at $2,411. Of the gold, about 70 per cent was obtained from siliceous gold ores and the remainder from placer deposits. Of the silver, about 90 per cent came from siliceous gold ores and the rest from placers. The gold ores, treated, yielded an average of $4.90 a ton in precious metals. The copper was derived from ore mined in Granville and Rowan counties, which yielded approximately 59 pounds of copper a ton.

As will be seen from the following table, the output of metals in North Carolina in 1916 shows a considerable reduction from the output in 1915. This is largely due to the suspension of operations at the Uwarra and Martha Washington properties in Montgomery County.

*Mine production of gold, silver, and copper in North Carolina, 1915–16.*

| Year. | Number of mines. | | Ore sold or treated. | Gold.[a] | Silver.[a] | Copper. | Total value. |
|---|---|---|---|---|---|---|---|
| | Placer. | Deep. | | | | | |
| | | | *Short tons.* | | *Fine ounces.* | *Pounds.* | |
| 1915 | 22 | 7 | 25,910 | $172,001 | 1,465 | 17,170 | $175,749 |
| 1916 | 20 | 6 | 3,918 | 26,237 | 663 | 9,800 | 29,084 |
| Decrease, 1916 | 2 | 1 | 21,992 | 145,764 | 802 | 7,370 | 146,665 |

[a] Includes placer.

There were 20 operators of placer mines in North Carolina in 1916, the largest being W. E. Sudlow at the Biggerstaff and Melton mines, Golden, Rutherford County. Placer gold was won in Burke, Cabarrus, Caldwell, Gaston, Macon, Mecklenburg, Montgomery, Randolph, Rowan, and Stanley counties, but the number of operators in each county and their individual production was relatively small.

Six deep mines were in operation for part or whole of the year in Cabarrus, Granville, Montgomery, Rowan, and Union counties. The largest production from deep mines was made by the Howie mine, at Waxhaw. The Uwarra mines, at Candor, operated for only a few months and are now reported to be shut down. The Rich Cog mines, at Eldorado, are still being developed, but the Martha Washington Mines Co. has abandoned its work.

At the Howie mine, in Union County, fire destroyed the shaft house, which was not repaired until December, 1916. The ore is treated at a 50-ton cyanide plant at the mine.

There is apparently some new development in the copper mines of the Virgilina district, which lie in Granville and Person counties, N. C.

The Ore Knob mine, in Ashe County, is under development, and it is said that a flotation plant to treat the copper ores will be installed early in 1918.

It is reported that drilling was done at the Silver Hill mine in Davidson County in 1916.

The Portis mine near Wood, Franklin County, has again been shut down after considerable prospecting and experimentation with methods to work this surface deposit.

The operators of Garden Hill mine near Greensboro, Guilford County, report that the mine has been reopened and the concentrating mill put into shape for production in 1917.

### PENNSYLVANIA.

The Cornwall iron mines in Lebanon County, now operated by the Bethleham Steel Co., produced a copper concentrate from pyritiferous magnetite ore.

### SOUTH CAROLINA.

In 1916 there was produced in South Carolina 15.48 ounces of gold and 28 ounces of silver, having a total value of $338, all from placer mines. This is the smallest production recorded for South Carolina since 1905, when the Survey began the collection of statistics of output in the Eastern States. The Haile mine is now operated for pyrite only, the gold veins not being worked.

The Sullivan Mining Co., operating the Dorn mine near McCormick, Abbeville County, is reported to be installing an amalgamation and concentration mill.

### TENNESSEE.

The mine production of precious metals in Tennessee in 1916 was 277.63 ounces of gold and 94,701 ounces of silver, having a combined value of $68,052, all of which was derived from the copper ores of Polk County. This is a reduction from the output in 1915.

No gold or silver ores were treated in the State, nor were the placer deposits of Monroe County operated. There were 482,495 tons of copper ore treated in Polk County, from which 14,679,794 pounds of copper were produced. Tennessee produced 32,960 pounds of lead, which was obtained from mines in Bradley and Union counties. The production of zinc in 1916 was 52,855,480 pounds, an increase of 19,932,578 pounds over the output in 1915. This large increase in zinc is in great part due to the operations of the American Zinc Co., at Mascot, Knox County, and the Embree Iron Co., at Embreeville, Washington County. Lead and zinc ores were also produced at mines in Bradley, Claiborne, Jefferson, and Union counties. The average content of zinc ore from Tennessee smelted direct in 1916 was 31 per cent, and the milling ore averaged 3.7 per cent zinc. It is reported that the options on land in Hancock County, held by S. T Wetherell, have been given up.

*Mine production of gold, silver, copper, lead, and zinc in Tennessee, 1915–16.*

| Year. | Number of mines. | | Ore sold or treated. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | Copper. | Lead and zinc. | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 2 | 7 | 1,149,364 | $6,862 | 100,543 | 18,046,010 | 1,660 | 32,922,902 | $7,296,406 |
| 1916 | 2 | 6 | 1,184,821 | 5,739 | 94,701 | 14,679,794 | 32,960 | 52,855,480 | 10,764,189 |
| Increase or decrease, 1916 | ..... | −1 | +35,457 | −1,123 | −5,842 | −3,366,216 | +31,300 | +19,932,578 | +3,465,783 |

## VERMONT.

The Union, Cuprum, and Eureka mines, Orange County, were operated by the Pike Hills Mines Co., which is experimenting with Wood flotation equipment after discontinuing a magnetic concentrator system.

The Vermont Copper Co. reopened the Elizabeth mine at South Strafford, Orange County, and installed a blast furnace for pyritic smelting of its ores.

## VIRGINIA.

The Virginia production of gold, silver, copper, lead, and zinc in 1916 was valued at $847,954, distributed as follows: Gold, 42.81 ounces, valued at $885; silver, 783 ounces, valued at $515; copper, 553,800 pounds, valued at $136,235; lead, 1,455,844 pounds, valued at $100,453; zinc, 4,551,237 pounds, valued at $609,866. The lead and zinc mines in Wythe and Pulaski counties were extensively developed and account for the great increase in the production of those metals, which were also produced from mines in Louisa, Tazewell, and Spotsylvania counties. Copper ore was shipped from mines in Buckingham, Charlotte, and Halifax counties.

*Mine production of gold, silver, copper, lead, and zinc in Virginia in 1915–16.*

| Year. | Number of mines. | | | Ore sold or or treated. | Gold. | Silver. |
|---|---|---|---|---|---|---|
| | Gold. | Copper. | Lead and zinc. | | | |
| | | | | *Short tons.* | | *Fine ounces.* |
| 1915 | 2 | 4 | 4 | 22,759 | $534 | ..... |
| 1916 | 1 | 3 | 7 | 39,262 | 885 | 783 |
| Increase or decrease, 1916 | −1 | −1 | +3 | +16,503 | +351 | +783 |

| Year. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 27,744 | 678,741 | 2,533,173 | $351,403 |
| 1916 | 553,800 | 1,455,844 | 4,551,237 | 847,954 |
| Increase or decrease, 1916 | +526,056 | +777,103 | +2,018,064 | +496,551 |

[a] Includes pyrite mines which produce lead and zinc.

The copper mines near Keysville, Charlotte County, and in the Virgilina district, Halifax County, have received considerable attention because of the value of the metal produced.

The Atlantic Lead & Zinc Co. developed a mine near Faber, Albemarle County, in 1916, and installed a 100-ton concentrating mill.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN COLORADO.[1]

(MINES REPORT.)

By CHARLES W. HENDERSON.

## PRODUCTION.

### GENERAL STATEMENT.

The total value of the production of gold, silver, copper, lead, and zinc in Colorado in 1916 was $49,200,675, an increase of 13 per cent as compared with the yield in 1915. Of the total value, gold represented only 39 per cent, with an output of $19,153,821, a decrease of $3,261,123. The value of the zinc output represented 37 per cent of the total, there being an increase of 29,690,469 pounds in quantity and of $5,024,473 in value. The increase in silver was 628,572 ounces in quantity and $1,474,824 in value. The production of copper, which is mostly incidental to the recovery of other metals, was 8,624,081 pounds, an increase of 1,511,544 pounds in quantity and of $876,830 in value. Lead increased 2,103,490 pounds in quantity and $1,658,974 in value.

The number of mines producing metals in Colorado in 1916 was 825 deep and 27 placer mines, as compared with 786 deep and 35 placer mines in 1915. This increase of 39 deep mines was confined chiefly to Chaffee, Eagle, Fremont, Ouray, and Summit counties, there being very little variation in the number of producing mines in the other counties.

### ORE.

The output of ore sold or treated from Colorado mines decreased 39,777 short tons in 1916 as compared with 1915.

During 1916 there were treated at amalgamating and cyaniding mills, including also a very small quantity sent to chlorinating mills, with or without concentration equipment (including all the custom mills of the State), 1,442,139 tons of ore having an average recovery as bullion or precipitates of 0.403 ounce of gold and 0.372 ounce of silver per ton. From 1,442,139 tons of ore treated at amalgamating, cyaniding, and chlorinating mills and from 702,200 tons sent to concentration and separation mills, a total to both classes of mills of 2,144,339 tons (79 per cent of the total tonnage treated, the same

[1] For discussion of the geology of the districts mentioned in the following pages the reader is directed to the bibliography given in Mineral Resources, 1912, pt. 1, pp. 704–705, 1913, and to U. S. Geol. Survey Bull. 507, The mining districts of the western United States, by J. M. Hill, with a geologic introduction by Waldemar Lindgren, 1912.

as in 1915), were produced 288,211 tons of concentrates—ratio of 7.44 to 1—with an average total value of $62.27 a ton, as compared with $55.16 a ton in 1915.

Crude ore shipped to lead and copper smelters amounted to 408,478 tons, averaging 0.50 ounce of gold and 11.32 ounces of silver per ton, and 0.77 per cent copper and 2.98 per cent lead. Crude ore to spelter and zinc oxide plants amounted to 144,426 tons, averaging 23.50 per cent zinc.

All classes of concentrates to lead and copper plants amounted to 165,349 tons, averaging 0.63 ounce of gold and 13.40 ounces of silver per ton, and 0.60 per cent copper and 12.24 per cent lead. Zinc and zinc-lead concentrates shipped to spelter and zinc oxide plants amounted to 122,862 tons, averaging 42.12 per cent zinc.

Crude ore and concentrates combined shipped to copper and lead plants, therefore, amounted to 573,827 tons, averaging 0.54 ounce of gold and 11.99 ounces of silver per ton, and 0.72 per cent copper and 5.65 per cent lead. Crude ore and concentrates combined shipped to spelter and zinc oxide plants amounted to 267,288 tons of 32.06 per cent zinc (original assay).

In 1916 there were 27 productive placers in Colorado which yielded $712,924 in gold and 9,189 fine ounces of silver, valued at $6,046, a total of $718,970, as compared with $697,705 in 1915.

*Mine production of gold, silver, copper, lead, and zinc in Colorado in 1915 and 1916.*[a]

| Year. | Number of producing mines. | Ore. | Gold. | | Silver.[b] |
|---|---|---|---|---|---|
| | | | Placer. | Deep. | |
| | | *Short tons.* | | | *Fine ounces.* |
| 1915 | 821 | 2,737,020 | $693,310 | $21,721,634 | 7,027,972 |
| 1916 | 852 | 2,697,243 | 712,924 | 18,440,897 | 7,656,544 |
| Increase or decrease, 1916 | +31 | −39,777 | +19,614 | −3,280,737 | +628,572 |

| Year. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 7,112,537 | 68,810,597 | 104,594,994 | $43,426,697 |
| 1916 | 8,624,081 | 70,914,087 | 134,285,463 | 49,200,675 |
| Increase or decrease, 1916 | +1,511,544 | +2,103,490 | +29,690,469 | +5,773,978 |

[a] A revised table showing the production of gold, silver, copper, lead, and zinc from the beginning of mining in Colorado to 1916 will be included in a separate chapter of Mineral Resources, "The history of Colorado mine production" (now in preparation).
[b] Includes placer production.

## GOLD.

The total production of gold in Colorado in 1916 was 926,566.09 fine ounces, valued at $19,153,821, a decrease of 157,756.83 fine ounces and $3,261,123 in value, following an increase in 1915 of $2,531,839 in value.

The Cripple Creek district, with a decrease of $1,563,944, produced $12,119,550 in gold, which is only a little larger than the production in 1914. Nevertheless, the production from the Cripple Creek district represented 63 per cent of the State yield in 1916.

The San Juan region, in Dolores, La Plata, Ouray, San Juan, and San Miguel counties, yielded $3,041,275, a decrease for the region of $813,246, following a decrease of $115,336 in 1915 and a decrease of $101,826 in 1914. Lake County yielded $1,720,440, a decrease of $525,712. There were decreases of $41,134 in Boulder, $131,096 in Chaffee, $97,652 in Clear Creek, $109,619 in Gilpin, $28,644 in Gunnison, $39,877 in La Plata, $626,841 in Ouray, and $145,053 in San Juan. The only increase of moment was in Park County.

Siliceous and dry ore, which was 76 per cent of all the ore sold or treated, yielded about 92 per cent of all the gold produced. A little more than 2 per cent came from lead ore, about 4 per cent from placers, more than 1 per cent from copper, and the remainder from lead-zinc, copper-lead, and zinc ores in the order named.

The output of placer gold from 27 placers in 1916 was $712,924, an increase of $19,614. Summit County, with 4 dredges and 5 hydraulic and sluice mines, produced 81 per cent, and 1 dredge in Lake County produced 17 per cent of the placer yield. The greater part of the remainder came from a dredge in Gunnison County and hydraulicking in Park County. There were also small placer yields in Chaffee, Clear Creek, Eagle, Moffat, and Routt counties.

## SILVER.

The yield of silver in Colorado in 1916 was 7,656,544 fine ounces, valued at $5,038,006, an increase of 628,572 fine ounces in quantity and of $1,474,824 in value, following a decrease of 1,768,093 fine ounces in 1915 and a decrease of 529,190 fine ounces in 1914.

Lake County for 1916 showed an increase of 360,279 ounces, Ouray an increase of 226,840 ounces, Pitkin an increase of 128,948 ounces, and there were also increases in Boulder, Clear Creek, Eagle, Mineral, Park, San Juan, and Summit. Chaffee County showed a decrease of 126,247 ounces, Dolores a decrease of 50,653 ounces, La Plata a decrease of 17,182 ounces, and San Miguel a decrease of 284,600 ounces.

Siliceous and dry ores yielded 73 per cent of the total; lead ores, 15 per cent; lead-zinc ores, 7 per cent; copper ores, about 3 per cent; copper-lead ores, more than 1 per cent; and zinc ores and placers furnished the remainder.

## COPPER.

The output of copper in 1916 was 8,624,081 pounds, valued at $2,121,524, an increase of 1,511,544 pounds in quantity and $876,830 in value. Copper has not been a very important mineral in the yield of the State, although it is quite widespread in the ores, but the high price of the metal for 1916 gave a gross value for the total production of considerable moment.

Lake County was the leading producer of copper, yielding nearly 30 per cent of the copper output; San Juan County was second, with 19 per cent; Chaffee was third, with 12 per cent.

Siliceous and dry ores yielded 57 per cent of the copper output; copper ores, nearly 35 per cent; lead ores, 4 per cent; copper-lead ores, more than 3 per cent; and lead-zinc and zinc ores, the remainder.

## LEAD.

The production of lead (in terms of lead in lead bullion and in leaded-zinc oxide) in Colorado in 1916 was 70,914,087 pounds, valued at $4,893,072, an increase of 2,103,490 pounds in quantity and $1,658,974 in value.

There was large increase in production in Clear Creek, Dolores, Lake, Park, San Juan, and San Miguel counties, and considerable increase in Eagle, Gunnison, and Saguache counties. The heaviest decrease was in Pitkin County. Pitkin and Lake counties are the principal sources of this metal. There was a decrease also in Boulder, Chaffee, Gilpin, La Plata, Mineral, Ouray, and Summit counties.

In rank, Lake County led, Pitkin was second, San Juan third, San Miguel fourth, Clear Creek fifth, and Chaffee, Ouray, Mineral, Summit, Eagle, Boulder, Dolores, and Gilpin followed in the order named. There was an increase in quantity of lead and zinc-lead ores produced, but there was a small decrease in the quantity of lead contained in these two classes of ore as compared with 1915.

Lead ores yielded nearly 39 per cent of the lead output; siliceous and dry ores, 33 per cent; lead-zinc ores, slightly less than 26 per cent; zinc ores, nearly 1 per cent; copper ores, 1 per cent; and copper-lead ores, the remainder.

## ZINC.[1]

In 1916 the marketed zinc ores from Colorado contained 134,285,463 pounds of recoverable zinc (as spelter and oxide), valued at $17,994,252, an increase of 29,690,469 pounds in quantity and of $5,024,473 in value.

Lead-zinc ores furnished 55 per cent of the total zinc yield; zinc ores, 39 per cent; and siliceous and dry ores, 6 per cent.

Lake County produced 76,785,567 pounds, an increase over the yield of 1915 of only 4,292,389 pounds; the output represents only 57 per cent of the total zinc output of the State, as compared with 69 per cent in 1915 and with 81 per cent in 1914. Leadville shipments of zinc carbonate were 85,513 tons of 21.52 per cent zinc, and the lead-zinc and zinc sulphide ores sold or treated in Leadville amounted to 147,295 tons of 21.69 per cent zinc.

The production of zinc in Eagle County was 28,438,052 pounds, an increase of 17,296,302 pounds. Summit County's production was 13,940,948 pounds, an increase of 5,343,537 pounds. There was also notable increase in Clear Creek, Gunnison, Mineral, and San Juan counties. The only decrease of importance was in Fremont, Park, and Pitkin counties.

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[1] For interesting discussion of zinc smelting and treatment of residues see Leslie, H. E., Zinc smelting at Bartlesville, Okla.; National Zinc Co., Bartlesville; Collinsville smelter of the Bartlesville Smelting Co., Hillsboro, Ill.; Rose Lake smelter of the Granby Co.; and Mineral Point smelter at Depue, Ill.; Min. and Sci. Press, vol. 109, pp. 44–49, July 11, 1914. Also see Stone, George C. (chief engineer New Jersey Zinc Co.), Belgian furnaces in zinc smelting; Min. and Sci. Press, Dec. 13, 1913, pp. 931–932. Stone, George C., Spelter—Manufacture and properties: Min. and Sci. Press, Nov. 14, 1914, pp. 754–759. Zinc smelter's roasting furnaces: Eng. and Min. Jour., Feb. 27, 1915, pp. 420–421. Donora Zinc Works: Min. Mag. (London), February, 1916, p. 114. Harris, T. N., New sulphuric acid plant (Donora, Pa.): Met. and Chem. Eng., Sept. 15, 1916, pp. 313–319. Simpson, W. P., The calcination of zinc carbonate: Met. and Chem. Eng., Feb. 15, 1916, pp. 181–183. Analysis and assay of zinc retort residues: Met. and Chem. Eng., Feb. 15, 1916, pp. 200–201.

The zinc output from concentrates in 1916 amounted to 78,731,912 pounds and from crude ore shipped direct to smelters to 55,553,551 pounds.

*Zinc ore and concentrates as marketed at the mine or mill[a] in Colorado in 1916.*

| County and district. | Classification. | Quantity. | Average assay of zinc content.[b] |
|---|---|---|---|
| | | *Short tons.* | *Per cent.* |
| Chaffee (ore and concentrates), Custer (ore), Gunnison (ore and concentrates), Hinsdale (ore), Park (ore), and Pitkin (ore). | Ore and concentrates | 12,515 | 33.68 |
| Lake | Zinc (lead) sulphide ore[c] | 150,312 | 21.36 |
| | Zinc carbonate ore | 85,908 | 21.56 |
| Clear Creek (ore and concentrates) | Ore and concentrates | 3,689 | 42.38 |
| Eagle and Summit (ore[c] and concentrates) | do | 82,834 | 33.58 |
| San Juan region: Dolores (ore), Mineral (concentrates), Ouray (ore and concentrates), San Juan (concentrates), and San Miguel (ore and concentrates). | do | 9,287 | 37.07 |
| | | 344,545 | 25.44 |
| SUMMARY. | | | |
| Lake | Crude ore | 236,220 | 21.43 |
| All other counties | Ore and concentrates | 108,325 | 34.19 |
| | | 344,545 | 25.44 |
| Total carbonate ore | Crude ore | 96,648 | 22.24 |
| Total sulphide ore | Ore and concentrates | 247,897 | 26.70 |

[a] Includes quantity of crude ore and contents as shipped to custom plants at Leadville, Pueblo, Canon City, and Denver, not the product of these mills, in order not to disclose individual milling operations.
[b] Assay of content; no deduction for loss in smelting.
[c] The bulk concentrated at Canon City, Denver, Pueblo, and Leadville, the remainder to spelter plants and zinc-oxide plants, chiefly in Kansas and Oklahoma, but also to eastern points. Concentrates were shipped to Kansas, Oklahoma, Illinois, Indiana, Wisconsin, Ohio, and Pennsylvania.

## OUTPUT OF ORE AND METAL CONTENT.

*Ore and metals produced in Colorado in 1916.*

| Source of production. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Placers | ..... | 34,487.70 | 9,189 | ..... | ..... | ..... |
| Dry and siliceous ore | 2,057,452 | 847,876.76 | 5,562,217 | 4,943,797 | 23,335,444 | 7,399,120 |
| Copper ore | 34,429 | 15,220.87 | 199,824 | 2,977,285 | 718,569 | ..... |
| Lead ore | 159,247 | 22,687.40 | 1,159,615 | 356,620 | 27,427,529 | ..... |
| Zinc ore | 151,497 | 330.62 | 58,722 | 6,349 | 589,991 | 52,873,099 |
| Copper-lead ore | 3,129 | 1,724.04 | 110,531 | 299,239 | 449,961 | ..... |
| Lead-zinc ore | 291,489 | 4,238.70 | 556,446 | 40,791 | 18,392,593 | 74,013,244 |
| Total, 1916 | 2,697,243 | 926,566.09 | 7,656,544 | 8,624,081 | 70,914,087 | 134,285,463 |
| Total, 1915 | 2,737,020 | 1,084,322.92 | 7,027,972 | 7,112,537 | 68,810,597 | 104,594,994 |
| Increase or decrease | −39,777 | −157,756.83 | +628,572 | +1,511,544 | +2,103,490 | +29,690,469 |

*Placer output in Colorado in 1916.*

| County. | Sluice and hydraulic. | | Dredges. | | Total. | |
|---|---|---|---|---|---|---|
| | Gold. | Silver. | Gold. | Silver. | Gold. | Silver. |
| | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* |
| Chaffee | 27.72 | 6 | ..... | ..... | 27.72 | 6 |
| Clear Creek | 12.09 | 5 | ..... | ..... | 12.09 | 5 |
| Eagle | 9.00 | ..... | ..... | ..... | 9.00 | ..... |
| Gunnison | 2.85 | ..... | ..... | ..... | 2.85 | ..... |
| Moffat | 46.39 | 3 | ..... | ..... | 46.39 | 3 |
| Park | 504.12 | 67 | ..... | ..... | 504.12 | 67 |
| Routt | 7.98 | 3 | ..... | ..... | 7.98 | 3 |
| Summit | 244.11 | 63 | ..... | ..... | 244.11 | 63 |
| Gunnison, Lake, and Summit | ..... | ..... | 33,633.44 | 9,042 | 33,633.44 | 9,042 |
| Total, 1916 | 854.26 | 147 | 33,633.44 | 9,042 | 34,487.70 | 9,189 |
| Total, 1915 | 1,012.22 | 174 | 32,526.65 | 8,495 | 33,538.87 | 8,669 |
| Increase or decrease | −157.96 | −27 | +1,106.79 | +547 | +948.83 | +520 |

*Content of dry and siliceous gold and silver ores sold or treated in Colorado in 1916.*

| County. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Boulder | 30,435 | 5,385.54 | 87,776 | 9,545 | 80,111 | ..... |
| Chaffee | 52,023 | 7,896.71 | 68,017 | 226,704 | 2,510,210 | 2,670,881 |
| Clear Creek | 69,597 | 16,087.04 | 221,430 | 374,123 | 2,000,455 | ..... |
| Custer | 1,547 | 90.74 | 29,155 | 41,871 | 69,404 | ..... |
| Dolores | 44 | 113.56 | 6,599 | ..... | 638 | ..... |
| Eagle | 3,621 | 1,533.18 | 153,824 | 17,927 | 12,757 | ..... |
| Fremont | 179 | 3.04 | 389 | 3,294 | 3,990 | ..... |
| Gilpin | 35,751 | 16,164.72 | 78,194 | 276,254 | 302,258 | ..... |
| Grand | 1 | ..... | 132 | ..... | ..... | ..... |
| Gunnison | 2,405 | 1,164.35 | 10,742 | 10,051 | 15,197 | ..... |
| Hinsdale | 94 | 19.23 | 3,055 | 1,539 | 2,044 | ..... |
| Lake | 210,539 | 67,039.88 | 2,353,243 | 1,948,315 | 4,019,927 | ..... |
| La Plata | 1,573 | 1,529.78 | 28,078 | 9,543 | 6,450 | ..... |
| Mineral | 21,466 | 751.62 | 362,784 | 7,651 | 730,586 | ..... |
| Montezuma | 60 | 67.34 | 146 | 85 | 116 | ..... |
| Ouray | 107,502 | 23,441.23 | 734,599 | 275,774 | 1,732,825 | 17,987 |
| Park | 107 | 20.06 | 1,778 | 782 | 2,941 | ..... |
| Pitkin | 9,762 | ..... | 131,128 | 11,467 | 224,514 | ..... |
| Routt | ..... | .24 | 214 | ..... | ..... | ..... |
| Saguache | 2,829 | 113.80 | 40,164 | 81,291 | 53,964 | ..... |
| San Juan | 132,394 | 18,579.74 | 341,616 | 1,062,805 | 5,494,844 | 3,646,161 |
| San Miguel | 428,194 | 100,085.98 | 803,108 | 563,864 | 6,031,238 | 1,064,091 |
| Summit | 1,509 | 1,505.75 | 26,242 | 912 | 40,975 | ..... |
| Teller | 945,820 | 586,283.23 | 79,804 | ..... | ..... | ..... |
| Total, 1916 | 2,057,452 | 847,876.76 | 5,562,217 | 4,943,797 | 23,335,444 | 7,399,120 |
| Total, 1915 | 2,183,431 | 1,012,897.34 | 5,195,593 | 4,370,439 | 21,811,059 | 6,219,566 |
| Increase or decrease | −125,979 | −165,020.58 | +366,624 | +573,358 | +1,524,385 | +1,179,554 |

*Content of copper ores sold or treated in Colorado in 1916.*[a]

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Baca | 5 | ..... | 50 | 2,772 | ..... |
| Boulder | 45 | 61.08 | 214 | 3,539 | ..... |
| Chaffee | 9,812 | 138.48 | 13,730 | 754,460 | 60,955 |
| Clear Creek | 1,181 | 1,856.65 | 29,180 | 117,330 | 57,856 |
| Custer | 1 | .07 | 333 | 53 | ..... |
| Dolores | 5,031 | 120.43 | 46,346 | 393,099 | 320,201 |
| Eagle | 1,419 | 2,410.33 | 13,781 | 80,337 | 177 |
| Fremont | 1,555 | 34.98 | 4,140 | 97,747 | 27,720 |
| Gilpin | 2,376 | 5,015.56 | 20,532 | 268,055 | 1,965 |
| Grand | 1 | ..... | 2 | 760 | ..... |
| Gunnison | 681 | 130.55 | 3,998 | 67,164 | 744 |

[a] All smelting ore.

*Content of copper ores sold or treated in Colorado in 1916*—Continued.

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Hinsdale | 46 | 6.65 | 820 | 5,024 | 2,525 |
| Jackson | 61 | 4.60 | 199 | 6,752 | ..... |
| Lake | 8,527 | 4,233.19 | 29,673 | 640,161 | 86,085 |
| La Plata | 29 | 1.43 | 1,109 | 2,481 | 101 |
| Moffat | 25 | .19 | 38 | 9,033 | ..... |
| Montezuma | 26 | .48 | 47 | 3,033 | ..... |
| Montrose | 197 | .48 | 1,132 | 100,008 | ..... |
| Ouray | 1,045 | 199.50 | 11,647 | 144,402 | 24,733 |
| Park | 28 | 8.93 | 139 | 1,855 | ..... |
| Routt | 517 | .44 | 20 | 32,142 | ..... |
| Saguache | 41 | 254.29 | 1,468 | 2,002 | 2,065 |
| San Juan | 1,638 | 685.86 | 18,351 | 235,189 | 122,202 |
| San Miguel | 147 | 56.70 | 2,875 | 9,887 | 11,130 |
| Total, 1916 | 34,429 | 15,220.87 | 199,824 | 2,977,285 | 718,569 |
| Total, 1915 | 23,573 | 6,204.17 | 204,317 | 2,169,383 | 244,667 |
| Increase or decrease | +10,856 | +9,016.70 | −4,493 | +807,902 | +473,902 |

*Content of copper-lead ores sold or treated in Colorado in 1916.*[a]

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Clear Creek | 566 | 572.79 | 17,012 | 72,494 | 89,165 |
| Custer | 8 | 1.11 | 102 | 716 | 2,391 |
| Hinsdale | 17 | .37 | 367 | 5,311 | 7,565 |
| Ouray | 114 | 10.74 | 1,475 | 8,912 | 28,967 |
| Saguache | 73 | 3.65 | 1,430 | 4,509 | 13,494 |
| San Juan | 2,328 | 1,127.45 | 89,688 | 206,216 | 310,453 |
| San Miguel | 23 | 7.93 | 457 | 1,081 | 2,996 |
| Total, 1916 | 3,129 | 1,724.04 | 110,531 | 299,239 | 449,961 |
| Total, 1915 | 2,674 | 2,098.50 | 98,210 | 212,678 | 641,982 |
| Increase or decrease | +455 | −374.46 | +12,321 | +86,561 | −192,021 |

[a] All smelting ore.

*Content of lead ores sold or treated in Colorado in 1916.*[a]

| County. | Ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* |
| Boulder | 2,531 | 324.48 | 204,334 | 51,623 | 784,222 |
| Chaffee | 2,381 | 887.36 | 18,721 | 10,990 | 437,533 |
| Clear Creek | 3,912 | 1,910.56 | 79,163 | 57,771 | 880,704 |
| Custer | 650 | 213.28 | 7,381 | 1,364 | 51,741 |
| Dolores | 891 | 124.28 | 24,203 | 26,401 | 172,776 |
| Eagle | 157 | 2.21 | 3,730 | 84 | 40,559 |
| Gilpin | 786 | 746.13 | 27,827 | 13,008 | 217,111 |
| Gunnison | 291 | 96.44 | 4,401 | 6,167 | 78,216 |
| Hinsdale | 192 | 38.35 | 5,349 | 3,891 | 54,900 |
| Lake | 21,954 | 4,054.41 | 178,224 | 31,364 | 4,597,216 |
| Ouray | 2,414 | 108.15 | 55,482 | 14,708 | 541,870 |
| Park | 2,785 | 10,796.02 | 11,203 | 19,961 | 327,584 |
| Pitkin | 104,163 | ..... | 442,419 | 17,464 | 17,207,739 |
| Saguache | 395 | 16.42 | 5,897 | 4,779 | 185,976 |
| San Juan | 3,768 | 662.18 | 44,865 | 87,944 | 939,394 |
| San Miguel | 140 | 90.05 | 4,716 | 2,671 | 61,068 |
| Summit | 11,837 | 2,617.08 | 41,200 | 6,435 | 849,120 |
| Total, 1916 | 159,247 | 22,687.40 | 1,159,615 | 356,620 | 27,427,529 |
| Total, 1915 | 142,969 | 26,068.24 | 964,224 | 338,041 | 27,482,225 |
| Increase or decrease | +16,278 | −3,380.84 | +195,391 | +18,579 | −54,696 |

[a] Nearly all smelting ore.

*Content of zinc ores sold or treated in Colorado in 1916.*[a]

| County. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Chaffee | 4,992 | 1.53 | 202 | 5,476 | 3,436 | 2,050,779 |
| Custer | 39 | ..... | ..... | ..... | ..... | 10,970 |
| Eagle | 8,527 | ..... | ..... | ..... | ..... | 4,588,981 |
| Gunnison | 6,506 | 9.53 | 6,204 | 534 | 170,624 | 1,860,646 |
| Lake | 88,925 | 102.94 | 27,897 | ..... | 93,531 | 30,952,194 |
| Park | 90 | 5.09 | 44 | ..... | 84 | 47,560 |
| Summit | 42,418 | 211.53 | 24,375 | 339 | 322,316 | 13,361,969 |
| Total, 1916 | 151,497 | 330.62 | 58,722 | 6,349 | 589,991 | 52,873,099 |
| Total, 1915 | 100,222 | 28.01 | 24,802 | 412 | 279,154 | 39,168,198 |
| Increase | 51,275 | 302.61 | 33,920 | 5,937 | 310,837 | 13,704,901 |

[a] Nearly all smelting ore.

*Content of lead-zinc ores sold or treated in Colorado in 1916.*[a]

| County. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Chaffee | 150 | ..... | 73 | 3,825 | 4,665 | 23,325 |
| Clear Creek | 18,964 | 310.40 | 115,351 | 14 | 1,267,545 | 2,572,575 |
| Dolores | 432 | .96 | 132 | ..... | 94,718 | 182,306 |
| Eagle | 91,425 | 691.02 | 50,791 | 14,262 | 1,463,869 | 28,849,071 |
| Gunnison | 536 | 21.45 | 3,646 | 763 | 48,436 | 104,227 |
| Hinsdale | 28 | .51 | 439 | 483 | 8,904 | 12,575 |
| Lake | 147,295 | 2,031.07 | 340,463 | 1,835 | 12,922,633 | 45,833,373 |
| Mineral | 16,637 | 754.00 | 11,172 | 5,487 | 1,564,501 | 240,575 |
| Ouray | 117 | .97 | 258 | 290 | 15,634 | 51,028 |
| Pitkin | 405 | ..... | 4,316 | ..... | 87,022 | 162,574 |
| San Juan | 6,000 | 163.40 | 7,822 | 3,013 | 418,321 | 368,242 |
| San Miguel | 147 | 11.35 | 885 | 3,924 | 20,119 | 34,394 |
| Summit | 9,353 | 253.57 | 21,098 | 6,895 | 476,226 | 578,979 |
| Total, 1916 | 291,489 | 4,238.70 | 556,446 | 40,791 | 18,392,593 | 74,013,244 |
| Total, 1915 | 284,151 | 3,487.79 | 532,157 | 21,584 | 18,351,510 | 59,207,230 |
| Increase | 7,338 | 750.91 | 24,289 | 19,207 | 41,083 | 14,806,014 |

[a] Nearly all concentrating ore.

## REDUCTION MILLS.

Mineral Resources for 1912, Part I, pages 650–664, contains a complete list of reduction mills in Colorado in 1912, with description of equipment and process. Changes of equipment have been noted in Mineral Resources for each year since 1912 in the text relating to the several counties, and reference should be made to the report for 1912 and those following for complete information in regard to any particular mill.

*Gold and silver produced at mills in Colorado, 1916.*

| County. | Ore to gold and silver mills. | Gold in bullion. | Silver in bullion. | Ore to concentrating mills. |
|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Short tons.* |
| Boulder | 14,666 | 2,914.90 | 1,594 | 14,248 |
| Chaffee | ..... | 99.56 | 26 | 52,627 |
| Clear Creek | 21,369 | 1,460.44 | 835 | 61,812 |
| Custer | ..... | 1.69 | 12 | ..... |
| Dolores | ..... | 5.30 | 11 | ..... |
| Eagle | ..... | 12.80 | 5 | 91,425 |
| Gilpin | 13,109 | 2,208.83 | 954 | 19,065 |
| Gunnison | 477 | 117.03 | 76 | 4,293 |
| Lake | 11,233 | 2,855.11 | 716 | 111,342 |
| La Plata | ..... | 35.33 | 10 | ..... |
| Mineral | 200 | 17.83 | 2,060 | 18,226 |
| Ouray | 61,412 | 14,153.90 | 97,766 | 41,924 |
| Park | 30 | 7.05 | 102 | ..... |
| Pitkin | ..... | ..... | ..... | 79,284 |
| San Juan | 52,195 | 3,182.00 | 1,173 | 82,185 |
| San Miguel | 411,887 | 61,413.15 | 384,805 | 16,260 |
| Summit | 100 | 1,350.10 | 636 | 56,261 |
| Teller | 855,461 | 491,342.74 | 45,972 | 53,248 |
| Total, 1916 | 1,442,139 | 581,177.76 | 536,753 | 702,200 |
| Total, 1915 | 1,611,335 | 662,304.68 | 608,072 | 557,267 |
| Increase or decrease | −169,196 | −81,126.92 | −71,319 | +144,933 |
| Average content per ton | ..... | 0.4030 | 0.3721 | ..... |

*Mine production of metals from Colorado concentrates in 1916.*

**By counties.**

| | Concentrates. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Boulder | 764 | 491.54 | 74,295 | 1,793 | 79,293 | ..... |
| Chaffee | 7,743 | 7,753.20 | 65,192 | 224,360 | 2,447,398 | 3,015,474 |
| Clear Creek | 15,123 | 10,839.38 | 257,274 | 292,934 | 2,594,534 | 2,535,172 |
| Eagle | 51,944 | 691.02 | 50,791 | 14,262 | 1,463,869 | 23,849,071 |
| Gilpin | 5,685 | 10,010.73 | 41,611 | 141,945 | 223,221 | ..... |
| Gunnison | 733 | 221.00 | 10,883 | 1,655 | 189,649 | 135,439 |
| Lake | 93,863 | 4,264.90 | 303,992 | 5,031 | 10,746,249 | 31,648,677 |
| Mineral | 2,459 | 776.36 | 13,494 | 5,569 | 1,676,763 | 240,575 |
| Ouray | 8,912 | 8,698.42 | 588,944 | 130,825 | 1,788,046 | 17,987 |
| Pitkin | 26,428 | ..... | 214,648 | 9,534 | 10,163,063 | ..... |
| San Juan | 20,809 | 13,534.63 | 319,891 | 951,112 | 5,635,202 | 4,014,403 |
| San Miguel | 26,930 | 38,552.20 | 417,874 | 563,150 | 6,029,774 | 1,064,091 |
| Summit | 21,543 | 392.57 | 47,888 | 6,050 | 902,933 | 12,211,023 |
| Teller | 5,275 | 10,370.25 | 2,229 | ..... | ..... | ..... |
| Total, 1916 | 288,211 | 106,596.20 | 2,409,006 | 2,348,220 | 43,939,994 | 78,731,912 |
| Total, 1915 | 233,965 | 128,015.39 | 2,214,689 | 2,270,790 | 43,565,115 | 53,954,312 |
| Increase or decrease | +54,246 | −21,419.19 | +194,317 | +77,430 | +374,879 | +24,777,600 |

**By kinds of concentrates.**

| | | | | | | |
|---|---|---|---|---|---|---|
| Dry and siliceous | 63,690 | 38,594.59 | 569,454 | 397,766 | 2,825,071 | ..... |
| Copper | 130 | 227.54 | 1,152 | 8,043 | 495 | ..... |
| Lead | 92,847 | 57,799.84 | 1,481,395 | 848,818 | 35,678,548 | ..... |
| Copper-lead | 8,682 | 6,821.95 | 163,559 | 726,986 | 1,983,377 | ..... |
| Total to lead and copper plants | 165,349 | 103,443.92 | 2,215,560 | 1,981,613 | 40,487,491 | ..... |
| Zinc and lead-zinc | 122,862 | [a] 3,152.28 | [a] 193,446 | [a] 366,607 | [b] 3,452,503 | [c] 78,731,912 |
| | 288,211 | 106,596.20 | 2,409,006 | 2,348,220 | 43,939,994 | 78,731,912 |

[a] Recovered in zinc residues.
[b] Lead recovered in zinc residues and in leaded zinc oxide.
[c] Zinc recovered as spelter and zinc in zinc oxide.

*Mine production of metals from Colorado concentrates in 1916*—Continued.

Average content.

| | Concentrates. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | | *Fine ounces per ton.* | *Fine ounces per ton.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Dry and siliceous | | 0.61 | 8.94 | 0.31 | 2.22 | |
| Copper | | 1.75 | 8.86 | 3.09 | .19 | |
| Lead | | .62 | 15.96 | .46 | 19.21 | |
| Copper-lead | | .79 | 18.84 | 4.19 | 11.42 | |
| Total average | | .63 | 13.40 | .60 | 12.24 | |
| Average content zinc and lead-zinc concentrates | | .03 | 1.57 | .15 | 1.40 | [a] 42.12 |

[a] Assay of content; no deduction for loss in smelting.

*Mine production of metals from Colorado crude ore shipped to smelters in 1916.*

By counties.

| | Crude ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Baca | 5 | | 50 | 2,772 | | |
| Boulder | 4,097 | 2,364.66 | 216,935 | 62,914 | 785,040 | |
| Chaffee | 16,731 | 1,071.32 | 35,525 | 777,095 | 569,501 | 1,729,511 |
| Clear Creek | 11,039 | 8,437.62 | 204,027 | 328,798 | 1,701,191 | 37,403 |
| Custer | 2,245 | 303.51 | 36,959 | 44,004 | 123,536 | 10,970 |
| Dolores | 6,398 | 353.93 | 77,269 | 419,500 | 588,333 | 182,306 |
| Eagle | 13,724 | 3,932.92 | 171,330 | 98,348 | 53,493 | 4,588,981 |
| Fremont | 1,734 | 38.02 | 4,529 | 101,041 | 31,710 | |
| Gilpin | 6,739 | 9,706.85 | 83,988 | 415,372 | 298,113 | |
| Grand | 2 | | 134 | 760 | | |
| Gunnison | 5,649 | 1,084.29 | 18,032 | 83,024 | 123,508 | 1,829,434 |
| Hinsdale | 377 | 65.11 | 10,030 | 16,248 | 75,638 | 12,575 |
| Jackson | 61 | 4.60 | 199 | 6,752 | | |
| Lake | 354,665 | 70,341.48 | 2,624,792 | 2,616,644 | 10,973,143 | 45,136,890 |
| La Plata | 1,602 | 1,495.88 | 29,177 | 12,024 | 6,551 | |
| Mineral | 19,677 | 711.43 | 358,402 | 7,569 | 618,324 | |
| Moffat | 25 | .19 | 38 | 9,033 | | |
| Montezuma | 86 | 67.82 | 193 | 3,118 | 116 | |
| Montrose | 197 | .48 | 1,132 | 100,008 | | |
| Ouray | 7,856 | 908.27 | 116,751 | 313,256 | 550,983 | 51,028 |
| Park | 2,975 | 10,823.05 | 13,062 | 22,598 | 330,609 | 47,560 |
| Pitkin | 35,046 | | 363,215 | 19,397 | 7,356,212 | 162,674 |
| Routt | 517 | .68 | 234 | 32,142 | | |
| Saguache | 3,338 | 388.16 | 48,959 | 92,581 | 255,449 | |
| San Juan | 11,748 | 4,502.00 | 181,278 | 664,055 | 1,650,102 | |
| San Miguel | 504 | 286.66 | 9,362 | 18,277 | 96,777 | 84,394 |
| Summit | 8,756 | 2,845.26 | 64,391 | 8,531 | 785,704 | 1,729,925 |
| Teller | 37,111 | 84,570.24 | 31,603 | | | |
| Total, 1916 | 552,904 | 204,304.43 | 4,701,596 | 6,275,861 | 26,974,093 | 55,553,551 |
| Total, 1915 | 568,418 | 260,463.98 | 4,196,542 | 4,841,747 | 25,245,482 | 50,640,682 |
| Increase or decrease | −15,514 | −56,159.55 | +505,054 | +1,434,114 | +1,728,611 | +4,912,869 |

By kinds of ore.

| | | | | | | |
|---|---|---|---|---|---|---|
| Dry and siliceous | 301,873 | 164,555.19 | 3,394,413 | 2,703,117 | 6,443,509 | |
| Copper | 34,429 | 15,220.87 | 199,824 | 2,977,285 | 718,569 | |
| Lead | 69,047 | 22,272.84 | 917,253 | 280,357 | 16,693,608 | |
| Copper-lead | 3,129 | 1,724.04 | 110,531 | 299,239 | 449,961 | |
| Total to lead and copper plants | 408,478 | 203,772.94 | 4,622,021 | 6,259,998 | 24,305,647 | |
| Zinc | 106,707 | 125.15 | 28,528 | 5,476 | 101,427 | 40,653,967 |
| Lead-zinc | 37,719 | 406.33 | 51,047 | 10,387 | 2,567,019 | 14,899,584 |
| Total to spelter and zinc oxide plants | 144,426 | [a] 531.49 | [a] 79,575 | [a] 15,863 | [b] 2,668,446 | [c] 55,553,551 |
| | 552,904 | 204,304.43 | 4,701,596 | 6,275,861 | 26,974,093 | 55,553,551 |

[a] Recovered in zinc residues.
[b] Lead recovered in zinc residues and in leaded zinc oxide.
[c] Zinc recovered as spelter and zinc in zinc oxide.

*Mine production of metals from Colorado crude ore, etc.*—Continued.

Average content.

| | Crude ore. | Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | | *Fine ounces per ton.* | *Fine ounces per ton.* | *Per cent.* | *Per cent.* | |
| Dry and siliceous | | 0.55 | 11.24 | 0.45 | 1.07 | ..... |
| Copper | | .44 | 5.80 | 4.32 | 1.04 | ..... |
| Lead | | .32 | 13.28 | .20 | 12.09 | ..... |
| Copper-lead | | .55 | 35.32 | 4.78 | 7.19 | ..... |
| Total average | | .50 | 11.32 | .77 | 2.98 | ..... |
| Zinc | | ..... | .27 | ..... | .05 | [a] 23.25 |
| Lead-zinc | | .01 | 1.35 | .01 | 3.40 | [a] 24.17 |
| Total average | | ..... | .55 | ..... | .92 | [a] 23.50 |

[a] Assay of content; no deduction for loss in smelting.

In 1916 Colorado mills consumed 5,237 pounds of quicksilver, 1 pound for every 77 pounds of ore, or 1 pound for every 8.85 ounces of gold and 4.51 ounces of silver; also 22,200 pounds of potassium cyanide and 1,082,617 pounds of sodium cyanide. The cyanides combined were used at the ratio of 0.86 pound per ton of ore or tailings treated, and for every pound used there were recovered 0.48 ounce of gold and 0.46 ounce of silver.

*Ore, concentrates, and tailings sent to amalgamation, cyanidation, and chlorination mills and gold and silver contained in bullion and precipitates in Colorado in 1916.*

| Process. | Quantity. | Gold in bullion. | Silver in bullion. |
|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* |
| Chlorination [a] | 200 | 4,366.50 | 2,150 |
| Amalgamation | [b] 402,735 | 46,345.76 | 23,612 |
| Cyanidation | [c] 1,282,516 | 530,465.50 | 510,991 |
| | ..... | 581,177.76 | 536,753 |

[a] In use in small way in Boulder County in treatment of "specimen" metallic gold and gold tellurides; in a new mill in Mineral County, where 200 tons of silver ore were treated in 1916; and in the treatment of stolen ore in Cripple Creek in small barrels, the gold given above being nearly all from Cripple Creek.

[b] Represents original crude ore; amalgamation in many cases followed by concentration or cyanidation or both. In one case amalgamation follows concentration.

[c] Represents original crude ore, concentrates, and tailings or slimes of ore first treated by amalgamation and concentration. In one case, that of a large custom mill, where ore is crushed in cyanide solution and the greater part of product is in form of cyanide precipitates, a very considerable quantity of the gold is recovered on blanket tables by use of mercury, the amalgamation bullion is credited to cyanidation.

## MINING INDUSTRY.

The total value of the production of gold, silver, copper, lead, and zinc in Colorado in 1916 was $49,200,675, an increase of 13 per cent. The increase is due almost entirely to the increased output of zinc and to the increased average prices for silver, copper, and lead.

The Globe, Leadville, Pueblo, Durango, and Salida smelters were operated continuously on ore from Canada, Colorado, Idaho, South Dakota, and other States, including a considerable and increased quantity of zinc residues from Kansas and Oklahoma zinc smelters.

The quantity of zinc residues sent to Colorado smelters has been increasing for several years. The United States Zinc Co.'s zinc smelter at Pueblo was operated steadily on zinc-lead ores from various counties in Colorado, and also from Arizona, Idaho, Montana, Nevada, and Utah; and the wet-concentration, magnetic-separation mill was also operated steadily on low-grade zinc-lead ore and concentrates from Leadville, Red Cliff, and Telluride. The Western Chemical Co.'s sulphuric acid, magnetic-separation, wet-concentration plant[1] at Denver was operated steadily at increased capacity, as was the Empire Zinc Co.'s 200-ton magnetic-separation plant[2] at Canon City, both treating chiefly Leadville and Red Cliff zinc-lead sulphide ores. The Western Zinc Oxide Co.'s plant[3] at Leadville was operated steadily throughout the year, the product being a zinc oxide for use as a pigment. The copper-matting plant at Ouray was operated for a short period, and the newly constructed copper-matting plant at Vulcan, Gunnison County, was also operated for a short time only. Cyanide precipitates and copper ore were shipped to the Omaha smelter, and copper ore and copper matte were shipped to Utah plants. Lead bullion and copper matte from lead plants in Colorado were sent to the Omaha smelter and to eastern refineries.

*Active smelting plants in Colorado in 1916.*

| City. | Plant. | Owner. | Class of ore. | Product. | Total furnaces.[a] |
|---|---|---|---|---|---|
| Denver | Globe | American Smelting & Refining Co. | Lead base[b] | Lead bullion and copper matte | 7. |
| Pueblo | Pueblo | do | do | do | 7. |
| Leadville | Arkansas Valley | do | do | do | 10. |
| Durango | Durango | do | do | do | 4. |
| Salida | Salida[c] | Ohio & Colorado Smelting & Refining Co. | do | do | 4. |
| Pueblo | United States Zinc Co. | American Smelting & Refining Co. | Zinc, lead, copper, gold, silver. | Spelter and zinc dust. | 1,944 retorts. |
| Ouray | Wanakah[d] | Wanakah Mining Co. | Pyritic copper | Copper matte | 2. |
| Florence | Florence (Old Rocky Mountain).[e] | River Smelting & Refining Co. | Zinc, lead, copper, gold, silver. | Zinc oxide, lead sulphate, copper matte. | Undergoing changes. |
| Leadville | | Western Zinc Oxide Co. | Zinc carbonate | Zinc oxide | 8 fire boxes. |
| Vulcan | Vulcan[d] | Vulcan Mines & Smelting Co. | Copper | Copper matte | 1. |

[a] Not all used.
[b] Copper ores and copper in other ores are handled by occasionally turning a lead furnace into a copper furnace.
[c] Weeks, F. D., The Salida smelter: Am. Inst. Min. Eng. Bull. 104, pp. 1691–1695, 1915.
[d] Operated for a short period only.
[e] Intermediate plant of River Smelting & Refining Co., Keokuk, Iowa, for production of electrolytic spelter.

The Golden Cycle and the Portland cyanidation mills, at Colorado Springs, were operated steadily. The Portland-Victor cyanide plant was operated steadily, but the Portland-Independence mill was operated only part of the year, the remainder of the year being occu-

[1] For description see Colorado State Bur. Mines Thirteenth Bienn. Rept. for 1913–14, pp. 150–151, 1914.
[2] For description see Livingston, A. R., Colorado State Bur. Mines Thirteenth Bienn. Rept. for 1913–14, pp. 100–101, 1914.
[3] For description see Leslie, E. H., Zinc pigments and Leadville works: Min. and Sci. Press, March 20, 1915, pp. 433–438; Met. and Chem. Eng., Sept. 15, 1915, pp. 631–633.

pied in remodeling and testing. Most of the small cyanide plants in the Cripple Creek district were operated for short periods only or were idle.

Lake County (Leadville and outlying districts) produced gold, silver, copper, lead, and zinc having a total gross value of $16,082,059, the largest in the history of mining in that county. The Arkansas Valley lead smelter and the zinc oxide plant were operated steadily throughout the year. The Pingrey concentration-flotation plant was also operated steadily and the Empire Zinc Co.'s concentration magnetic-separation mill, at Canon City, was operated with increased capacity on Leadville zinc sulphide ores, as was the Western Chemical Co.'s wet concentration magnetic-separation plant at Denver. The unwatering of the Downtown districts by electric pumps reached a depth sufficient to commence retimbering and development from the Penrose shaft, and in November shipments of manganese ore were begun and later shipments of zinc carbonate were made. The unwatering begun at the Harvard shaft, on Fryer Hill, was also successful, and zinc carbonate and iron-silver sulphide ores were shipped from the unwatered district during the year. The dredge installed on Arkansas River, below Malta, in 1915, with a production in that year of $69,000 in placer gold in 70 days, yielded $119,169 during 1916. The Lackawanna Gulch district continued to be active, with shipments of bullion, high-grade gold ore, and concentrates, and silver ore in quantity continued to be shipped from the Sugar Loaf district. Considerable zinc-lead sulphide ore was shipped from the St. Kevin district, and lead and zinc carbonate ores were mined and shipped from the Weston Pass district. Lead-zinc mines at Wortman were also reopened during the year and ore was shipped.

The value of the output of Eagle County (chiefly Red Cliff, but also including a considerable quantity of silver from the Brush Creek district) greatly exceeded the output in 1915, which had been the largest since the discovery of ore at Red Cliff in 1879.

The yield of placer gold from Summit County dredges and placers was not equal to the output of 1915, but there was an increase in lode gold from that county which almost compensated for the decrease in placer output, and the production of zinc in quantity and in value greatly exceeded the output in 1915, which had been the largest ever recorded.

Park County showed increases for all metals except for zinc, and the total gross value showed an appreciable increase.

The Pitkin County (Aspen) output showed a small increase in quantity of silver produced and a considerable decrease in quantity of lead, but the value of the output showed a very large increase.

Gunnison County's output showed increase in all metals except gold.

Chaffee County's output showed a heavy decrease in gold, a decrease in the quantity of silver and lead produced, but a considerable increase in quantity of copper and an appreciable increase in total value of output.

The high price of copper caused considerable activity in the various districts of Fremont County and also the revival of mining in the Pearl copper district in Jackson County.

Operations were resumed at the Rawley mine, in Saguache County, and the production from this property, with others in the Bonanza district, resulted in an appreciable increase for Saguache.

The San Juan region of Dolores, La Plata, Ouray, San Juan, and San Miguel counties produced $3,041,275 in gold, 2,224,311 ounces of silver, 3,072,199 pounds of copper, 16,345,768 pounds of lead, and 5,364,209 pounds of zinc, with a total value of $7,107,294, as compared with $3,854,521 in gold, 2,278,201 ounces of silver, 3,517,462 pounds of copper, 14,314,363 pounds of lead, and 3,342,565 pounds of zinc, with a total value of $6,712,378 in 1915.

Mineral County (Creede) showed an increase in quantity of silver and zinc and a small decrease in quantity of lead, but an increase in total value of 50 per cent.

Boulder, Gilpin, and Clear Creek counties produced 166,144 tons of ore yielding $1,001,489 in gold, 881,518 ounces of silver, 1,243,756 in copper, 5,681,392 pounds of lead, and 2,572,575 pounds of zinc, with a total value of $2,624,233, as compared with 214,823 tons of ore yielding $1,249,894 in gold, 790,065 ounces of silver, 1,094,012 pounds of copper, 4,008,744 pounds of lead, and 1,516,032 pounds of zinc, with a total value of $2,218,302 in 1915.

*Mine production of gold, silver, copper, lead, and zinc in Colorado in 1916.*

| County. | Producing mines. | Ore sold or treated. | Gold. | | Silver. | |
|---|---|---|---|---|---|---|
| | | | Quantity. | Value. | Quantity. | Value. |
| | | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | |
| Baca | 1 | 5 | | | 50 | $33 |
| Boulder | 81 | 33,011 | 5,771.10 | $119,299 | 292,824 | 192,678 |
| Chaffee | 35 | 60,358 | 8,951.80 | 185,050 | 100,749 | 66,293 |
| Clear Creek | 100 | 94,220 | 20,749.53 | 428,931 | 462,141 | 304,089 |
| Custer | 14 | 2,245 | 305.20 | 6,309 | 36,971 | 24,327 |
| Dolores | 13 | 6,398 | 359.23 | 7,426 | 77,280 | 50,850 |
| Eagle | 32 | 105,149 | 4,645.74 | 96,036 | 222,126 | 146,159 |
| Fremont | 11 | 1,734 | 38.02 | 786 | 4,529 | 2,980 |
| Gilpin | 87 | 38,913 | 21,926.41 | 453,259 | 126,553 | 83,272 |
| Grand | 2 | 2 | | | 134 | 88 |
| Gunnison | 18 | 10,419 | 1,526.38 | 31,553 | 29,023 | 19,097 |
| Hinsdale | 18 | 377 | 65.11 | 1,346 | 10,030 | 6,600 |
| Jackson | 1 | 61 | 4.60 | 95 | 199 | 131 |
| Lake | 96 | 477,240 | 83,226.29 | 1,720,440 | 2,931,281 | 1,928,783 |
| La Plata | 36 | 1,602 | 1,531.21 | 31,653 | 29,187 | 19,205 |
| Mineral | 9 | 38,103 | 1,505.62 | 31,124 | 373,966 | 246,063 |
| Moffat | 5 | 25 | 46.58 | 963 | 41 | 27 |
| Montezuma | 3 | 86 | 67.82 | 1,402 | 193 | 127 |
| Montrose | 2 | 197 | .48 | 10 | 1,132 | 745 |
| Ouray | 52 | 111,192 | 23,760.59 | 491,175 | 803,461 | 528,677 |
| Park | 15 | 3,005 | 11,334.22 | 234,299 | 13,231 | 8,706 |
| Pitkin | 12 | 114,330 | | | 577,863 | 380,234 |
| Routt | 4 | 517 | 8.66 | 179 | 237 | 156 |
| Saguache | 20 | 3,338 | 388.16 | 8,024 | 48,959 | 32,215 |
| San Juan | 46 | 146,128 | 21,218.63 | 438,628 | 502,342 | 330,541 |
| San Miguel | 20 | 428,651 | 100,252.01 | 2,072,393 | 812,041 | 534,323 |
| Summit | 55 | 65,117 | 32,599.47 | 673,891 | 120,207 | 79,096 |
| Teller | 64 | 945,820 | 586,283.23 | 12,119,550 | 79,804 | 52,511 |
| Total, 1916 | 852 | 2,697,243 | 926,566.09 | 19,153,821 | 7,656,544 | 5,038,006 |
| Total, 1915 | 821 | 2,737,020 | 1,084,322.92 | 22,414,944 | 7,027,972 | 3,563,182 |
| Increase or decrease | +31 | −39,777 | −157,756.83 | −3,261,123 | +628,572 | +1,474,824 |

*Mine production of gold, silver, copper, lead, and zinc in Colorado in 1916*—Continued.

| County. | Copper. | | Lead. | | Zinc. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Baca | 2,772 | $682 | | | | | $715 |
| Boulder | 64,707 | 15,918 | 864,333 | $59,639 | | | 387,534 |
| Chaffee | 1,001,455 | 246,358 | 3,016,899 | 208,166 | 4,744,985 | 635,828 | 1,341,695 |
| Clear Creek | 621,732 | 152,946 | 4,295,725 | 296,405 | 2,572,575 | 344,725 | 1,527,096 |
| Custer | 44,004 | 10,825 | 123,536 | 8,524 | 10,970 | 1,470 | 51,455 |
| Dolores | 419,500 | 103,197 | 588,333 | 40,595 | 182,306 | 24,429 | 226,497 |
| Eagle | 112,610 | 27,702 | 1,517,362 | 104,698 | 28,438,052 | 3,810,699 | 4,185,294 |
| Fremont | 101,041 | 24,856 | 31,710 | 2,188 | | | 30,810 |
| Gilpin | 557,317 | 137,100 | 521,334 | 35,972 | | | 709,603 |
| Grand | 760 | 187 | | | | | 275 |
| Gunnison | 84,679 | 20,831 | 313,217 | 21,612 | 1,964,873 | 263,293 | 356,386 |
| Hinsdale | 16,248 | 3,997 | 75,838 | 5,219 | 12,575 | 1,685 | 18,847 |
| Jackson | 6,752 | 1,661 | | | | | 1,887 |
| Lake | 2,621,675 | 644,932 | 21,719,392 | 1,498,638 | 76,785,567 | 10,289,266 | 16,082,059 |
| La Plata | 12,024 | 2,958 | 6,551 | 452 | | | 54,268 |
| Mineral | 13,138 | 3,232 | 2,295,087 | 158,361 | 240,575 | 32,287 | 471,017 |
| Moffat | 9,033 | 2,222 | | | | | 3,212 |
| Montezuma | 3,118 | 767 | 116 | 8 | | | 2,304 |
| Montrose | 100,008 | 24,602 | | | | | 25,357 |
| Ouray | 444,081 | 109,244 | 2,339,029 | 161,393 | 69,015 | 9,248 | 1,299,737 |
| Park | 22,598 | 5,559 | 330,609 | 22,812 | 47,560 | 6,373 | 277,749 |
| Pitkin | 28,931 | 7,117 | 17,519,275 | 1,208,830 | 162,574 | 21,785 | 1,617,966 |
| Routt | 32,142 | 7,907 | | | | | 8,242 |
| Saguache | 92,581 | 22,775 | 255,449 | 17,626 | | | 89,640 |
| San Juan | 1,615,167 | 397,331 | 7,285,304 | 502,686 | 4,014,403 | 537,930 | 2,207,116 |
| San Miguel | 581,427 | 143,031 | 6,126,551 | 422,732 | 1,098,485 | 147,197 | 3,319,676 |
| Summit | 14,581 | 3,587 | 1,688,637 | 116,516 | 13,940,948 | 1,868,087 | 2,741,177 |
| Teller | | | | | | | 12,172,061 |
| Total, 1916 | 8,624,081 | 2,121,524 | 70,914,087 | 4,893,072 | 134,285,463 | 17,994,252 | 49,200,675 |
| Total, 1915 | 7,112,537 | 1,244,694 | 68,810,597 | 3,234,098 | 104,594,994 | 12,969,779 | 43,426,697 |
| Increase | 1,511,544 | 876,830 | 2,103,490 | 1,658,974 | 29,690,469 | 5,024,473 | 5,773,978 |

## REVIEW BY COUNTIES.

### BACA COUNTY.

A car of silver-copper ore was shipped from the Carrizo Creek district, in the southeast corner of this county. The ore is chalcocite, partly altered to malachite and azurite, in white sandstone.

During the years 1900–1902 there was considerable activity in this district and small shipments of ore were made. A little work was also done in 1915 and a small shipment was made that year. The distance to a railroad (70 miles) handicaps production in the district.

### BOULDER COUNTY.

*Mine production in Boulder County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 113 | 39,778 | $160,433 | 271,292 | 86,680 | 890,042 | $354,979 |
| 1916 | 81 | 33,011 | 119,299 | 292,824 | 64,707 | 864,333 | 387,534 |
| Increase or decrease, 1916 | −32 | −6,767 | −41,134 | +21,532 | −21,973 | −25,709 | +32,555 |

The value of the mine production of Boulder County in 1916 was the largest since 1904. There was a decreased output in all the districts of Boulder County with the exception of Sugar Loaf and Ward districts. There was a decrease in the county in quantity of all the metals produced except silver, which showed an increase of 21,532 ounces in quantity; but with the increased average price for that metal during 1916 there was an increase in its total value of $55,133. There was a small decrease in the quantity of lead produced, but the value of this metal showed an increase. The production of gold fell off $41,134.

There was a small increase in the quantity of ore milled at gold and silver mills, with an increase in gold in bullion but a decrease in silver, and there was a heavy decrease in the quantity of ore milled at plants for concentration only and a very considerable decrease in the quantity of concentrates produced, with a resultant heavy decrease in the quantity of gold in concentrates, but the output of silver in concentrates was almost equal to that of 1915. The quantity of smelting ore decreased from 5,322 tons to 4,097 tons, and the contents of smelting ore showed a considerable decrease in gold, but an appreciable increase in silver and a small increase in lead.

*Central district.*—The production of the Central district (near Jamestown) was 680 tons of ore, carrying $5,220 in gold, 23,731 ounces of silver, 28,764 pounds of copper, and 296,870 pounds of lead, with a total value of $48,395, as compared with $50,582 in 1915. With the exception of a small quantity of metallic gold from the Gold Nugget mine, all the ore was shipped to smelters. The output from this district for 1915 and 1916 was the largest for several years. The principal producing mine in the district was the Alice, from which a considerable quantity of silver-lead-gold ore was shipped. Other producing mines were the Argo, Eureka, Golden Age, Princess, Rip Van Dam, and Wano.

*Gold Hill district.*—The production of the Gold Hill district was 2,163 tons of ore, carrying $16,074 in gold, 3,467 ounces of silver, 1,793 pounds of copper, and 5,348 pounds of lead, with a total value of $19,165, as compared with $47,798 in 1915. The bulk of the ore mined in the district was concentrated, but the smelting ore shipped contained the greater part of the metals produced in the district. The principal producing mine was the Big Horn, from which gold-silver ore was shipped direct to smelters. The ore from the White Rock and Altruist mines, operated by the Illinois Mining Co., was treated in the company's flotation mill. Some ore from the Prussian and Slide mines was treated in a small concentration plant near the property. Other important producing mines were the Atchison, Dead Medicine, Emerson, Fairfax, Gillespie, Gold Medal, Nil Desperandum, Poorman-Relief, and Snowbound.

*Grand Island district (Cardinal, Caribou, Eldora, Nederland).*[1]—This district, revived in 1914, and the principal producing district in the county in 1915, did not maintain its output in 1916, the yield being 12,816 tons of ore, carrying $6,520 in gold, 97,404 ounces of silver, 2,557 pounds of copper, and 110,275 pounds of lead, with a total value of $78,850, as compared with $130,296 in 1915.

[1] George, R. D., and Crawford, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Ann. Rept., pp. 7–105, 1909. (Reprint with additions, pp. 1–122, 1916.)

The Caribou Mines & Mills Co. (successor to a company which in 1914 had taken over the old Caribou group and which had built a 100-ton cyanide plant at the Caribou mine) installed the flotation process at the mill and operated the plant as a concentration mill only for the greater part of the year. Other producing mines at Caribou were the Bernice and the Up To Date. There was a small shipment of ore from the Lost Lake mine at Eldora.

*Magnolia district.*[1]—The Magnolia district in 1916 produced 293 tons of ore, carrying $8,215 in gold, and 294 ounces of silver, with a total value of $8,408, as against $12,081 in 1915. All the ore was shipped to smelters. The principal producing mines were the Eclipse, Graphic, Keystone, Magnolia, Mountain Lion, and Red Signe.

*Sugar Loaf district.*—The total value of the output of this district showed a very considerable increase in 1916. The output of ore was 15,529 tons, which yielded $71,237 in gold, 42,363 ounces of silver, 4,118 pounds of copper, and 23,348 pounds of lead, with a total value of $101,736, as compared with $60,965 in 1915. The principal producing property was that of the United States Gold Corporation, whose roasting and cyanidation 150-ton mill was operated steadily throughout the year. From the Logan mine there continued to be shipped considerable gold bullion from free-milling ore treated in a small laboratory plant; in addition, several cars of a good grade of smelting ore were shipped. A large quantity of silver-lead ore was shipped from the Yellow Pine mine. Other producing properties were the Bald Mountain, Doss, Gold Coin, Golden Chest, Great Britain, and Wood Mountain.

*Ward district.*—The Ward district in 1916 was the principal producing district in the county, with a yield of 1,521 tons of ore, carrying $11,781 in gold, 125,556 ounces of silver, 27,475 pounds of copper, and 428,492 pounds of lead, with a total value of $130,722, as against $52,747 in 1915. Nearly all the ore was shipped to smelters. A small quantity of ore was treated at the Humboldt concentration mill, but after a very short period of operation the mine was abandoned and all buildings removed. The principal producing mine in the district was the White Raven, from which a large quantity of silver-lead ore was shipped. Other producing mines were the Columbia, Black Jack, Golden Queen, Idaho, Innspruck, Nelson, and Sullivan No. 5.

## CHAFFEE COUNTY.

*Mine production in Chaffee County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine. ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 15 | 68,240 | $316,146 | 226,996 | 348,046 | 3,630,127 | 4,676,355 | 1,242,625 |
| 1916 | 35 | 69,358 | 185,050 | 100,749 | 1,001,455 | 3,016,899 | 4,744,985 | 1,341,695 |
| Increase or decrease, 1916 | +20 | +1,118 | −131,096 | −126,247 | +653,409 | −613,228 | +68,630 | +99,070 |

[1] George R. D., and Crawford, R. D., op. cit.
[a] Includes placer production.

*Chalk Creek district.*—The Mary Murphy mine, in this district, is the principal producing mine in the county, and as a result of its operations the Chalk Creek district has for several years been the most important in the county. The ore minerals of the Mary Murphy, arranged in order of quantity, are zinc blende, galena, pyrite, and chalcopyrite, with cerusite, anglesite, and a little malachite and native sulphur in the oxidized zone; the depth of the zone from the surface is irregular and varies with different veins. The gangue, in the upper levels, consists of rhodonite and quartz, with a little calcite; in the lower levels it consists mostly of quartz and clay, with calcite and a little fluorite. Gold occurs both in the ore and in the gangue minerals, but decreases in quantity and becomes strikingly irregular in distribution in the deeper workings. Silver ore also occurs both in the ore and in the gangue minerals and lessens in quantity with depth to a greater degree than the gold.

A decreased quantity of ore was milled in the company's mill[1] (built in 1912), a wet concentration plant, with electrostatic separation of zinc, iron, and copper; to this plant a flotation plant for the treatment of slimes only was added in 1915. The production of crude ore, both by lessees and on company account, showed a great reduction, which will probably be still more marked during 1917.

The annual report of the general manager of the Mary Murphy Gold Mining Co. for the year ending December 31, 1916, says:

> Milling operations continued throughout the year, with few interruptions, on a basis of about 150 tons daily, it having been found impossible to supply more than this tonnage from the mine. The ore averaged considerably lower in grade, as will be observed from the comparative tonnage of all descriptions of products shipped. The zinc concentrates, moreover, realized a notably lower price, due to the decline in spelter. The lead and iron-copper concentrates realized more, but not nearly enough to counterbalance the falling off in the zinc products.
>
> The use of flotation has been continued on both slime and reground tailing, but the results have not realized my earlier hopes. Especially in the case of the ore from the upper levels, a notable percentage of the zinc is oxidized and therefore not amenable to flotation. We are, however, losing a good deal of unoxidized mineral, and the problem of saving it in marketable form is a difficult one. As is well known, zinc concentrates, unless they can be brought up to about 35 per cent grade, are practically unmarketable, and it is difficult to secure at once high saving and quality of product. * * *
>
> The developments during the year opened up notably less ore than extracted, with the result that at its close the reserves of ore broken and proved were very small. As I stated in my last annual report, most of the ground which we are now mining is of such low grade that it could not be regarded as ore at all excepting for the present high metal prices.
>
> In the Iron Chest mine I estimate that at the close of the year we had about 6,000 tons of milling ore broken and reasonably proved. In the Mary Murphy about 4,000 tons in all were broken and, perhaps, an equal tonnage proved.
>
> The ore supply for the mill is therefore precarious, and unless we are successful in opening up larger ore bodies during the coming year milling operations will necessarily have to be suspended.
>
> During the year the ore milled and the ore and mill products shipped were as follows, as compared with the corresponding figures for 1913 to 1915:

[1] For description and flow sheet see Parmelee, H. C., Concentration of complex sulphide ore from the Mary Murphy mine: Met. and Chem. Eng., January, 1914, pp. 21–26. See also Collins, G. E., Colorado Bur. Mines Thirteenth Bien. Rept. for 1913–14, pp. 65–71, 1914.

| | 1913 | | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. | Tons. | Value. | Tons. | Value. |
| Into concentration mill | 34,271 | ..... | 48,526 | ..... | 55,880 | ..... | 51,116 | ..... |
| Lead concentrates | ..... | ..... | ..... | ..... | 1,925 | $168,484 | 1,587 | $171,788 |
| Iron-copper concentrates | ..... | ..... | ..... | ..... | 1,741 | 43,470 | 1,635 | 58,323 |
| Zinc concentrates | ..... | ..... | ..... | ..... | 4,700 | 327,570 | 3,971 | 227,459 |
| Company concentrates | 4,069 | $160,136 | 6,137 | $211,217 | 8,367 | 539,524 | 7,193 | 457,571 |
| Company bullion (ounces) | 477 | 5,626 | 425 | 5,289 | 50 | 614 | ..... | ..... |
| Company crude ore | 1,604 | 62,538 | 3,298 | 83,653 | 2,642 | 61,076 | 149 | 2,651 |
| Tributers' crude ore | 5,904 | 168,287 | 3,744 | 99,850 | 1,830 | 38,931 | 622 | 17,470 |

*Cleora district.*[1]—Several cars of copper ore were shipped from this district.

*Cottonwood Creek district.*—For the first time in many years there was a quantity of ore carrying lead, copper, silver, and gold from various properties on South Cottonwood Creek. Properties from which some production was made were the Cora-Bell-Geneva-Annie and Reserve-Laura Louise-William Penn claims.

*Granite district.*—There was a small production of placer gold in this district, and two small lots of ore were shipped from the Benton Falls and Mascot mines.

*La Plata district.*—A small lot of lead-silver ore was shipped from the Banner No. 1 claim.

*Monarch district.*[2]—From 15 mines 6,363 tons of ore were shipped, which yielded $1,249 in gold, 10,614 ounces of silver, 107,004 pounds of copper, 355,522 pounds of lead, and 1,700,224 pounds of zinc, with a total value of $286,917, as compared with $251,090 in 1915.

The Madonna mine was again the chief producer.[3] From lessees on the upper levels lead oxidized, zinc oxidized, and iron oxidized ore was shipped from this property. Development work was continued on the lower levels. Other producing mines were the Fairplay, Little Giant, Jewel group, Major, Silent Friend, Lilly, and Wilson. The Garfield mine[4] was idle.

*Turret district (including Sedalia).*[5]—Lessees operating the Sedalia mine shipped a large quantity of silver-copper oxidized ore to lead plants and also a considerable quantity of zinc sulphide ore to the Pingrey flotation plant, at Leadville, and to the River smelter, at Florence.

[1] Lindgren, Waldemar, Notes on copper deposits in Chaffee, Fremont, and Jefferson counties, Colo.: U. S. Geol. Survey Bull. 340, pp. 157–174, 1908.
[2] For discussion of the geology of the district see Crawford, R. D., Geology and ore deposits of the Monarch and Tomichi districts, Colo.: Colorado State Geol. Survey Bull. 4, 1913.
[3] For the total output of the mine, including 1911, see Crawford, R. D., idem, p. 239.
[4] Crawford, R. D., idem, p. 262.
[5] Lindgren, Waldemar, op. cit.

## CLEAR CREEK COUNTY.[1]

*Mine production in Clear Creek County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 102 | 121,993 | a$526,583 | a 393,108 | 530,949 | 2,527,575 | 1,505,032 | $1,124,225 |
| 1916 | 100 | 94,220 | a 428,931 | a 462,141 | 621,732 | 4,295,725 | 2,572,575 | 1,527,096 |
| Increase or decrease, 1916 | −2 | −27,773 | −97,652 | +69,033 | +90,783 | +1,768,150 | +1,067,543 | +402,871 |

a Includes small placer production.

In 1916 the value of the mine production of Clear Creek County was the largest since 1901. The quantity of ore sold or treated decreased appreciably, and the yield of gold decreased very considerably, but the yield of all the other metals increased in quantity, and with the high prices for the year the values increased very greatly. An increase was shown from both the lower Clear Creek mines (Idaho Springs, Cascade, Jackson, Montana, and Trail districts combined) and the upper Clear Creek mines (Alice, Argentine, Empire, and Griffith districts), but the increase in gross value for the upper Clear Creek mines represented 69 per cent of the increase. The upper Clear Creek mines showed a decreased production of $18,527 in gold but an increased production of 78,417 ounces of silver, 5,929 pounds of copper, 537,023 pounds of lead, and 1,043,720 pounds of zinc. Lower Clear Creek mines showed a decrease of $69,125 in gold and 9,385 ounces of silver but an increase of 84,856 pounds of copper, an increase of 1,231,127 pounds of lead, and an increase of 23,823 pounds of zinc.

Small sluicing operations below the town of Idaho Springs yielded a small quantity of placer gold.

*Alice (Yankee) district.*—The output of Alice district was $1,333, mostly gold, as compared with $3,275 in 1915. A small quantity of ore from the Yukon mine was milled in one of the small amalgamation-concentration mills in the district. Several lots of ore from the Ottawa mine were shipped to the sampler and to the Argo mill at Idaho Springs. A small quantity of ore from the Reynolds mine was treated in the five-stamp amalgamation-concentration mill on the property.

*Argentine district.*—The Argentine district produced from three mines 2,970 tons of ore yielding $31,327 in gold, 43,429 ounces of silver, 154,988 pounds of copper, and 206,841 pounds of lead, with a total valuation of $112,302, nearly equal to the 1915 output of $113,557, although there was an increase in metallic content of silver and copper only.

[1] For discussion of geology see Spurr, J. E., and Garrey, G. H., Preliminary report on the ore deposits of the Georgetown mining district, Colorado: U. S. Geol. Survey Bull. 285, pp. 35–40, 1906; Economic geology of the Georgetown quadrangle (together with the Empire district), Colorado, with general geology by S. H. Ball: U. S. Geol. Survey Prof. Paper 63, 422 pp., 1906; Bastin, E. S., and Hill, J. M., Economic geology of Gilpin County and adjacent parts of Clear Creek and Boulder counties, Colo.: U. S. Geol. Survey Prof. Paper 94, 1917.

A large quantity of copper-lead ore was shipped from the Santiago mine. Lead-copper ore was also shipped from the Waldorf mine, and a considerable quantity of ore was concentrated at the mill on the property.

*Empire (Upper Union) district.*—The Empire district in 1916 from 5 mines produced 455 tons, yielding $4,401 in gold, 6,954 ounces of silver, 44,072 pounds of copper, and 10,284 pounds of zinc, with a total value of $13,396, as compared with $16,659 in 1915. As usual, most of the ore from this district was treated by milling, either in the district or at Idaho Springs, only 121 tons being sent to smelters.

The only mill operating in the district was the Golden Empire, the rest of the milling ore being sent to the Argo mill at Idaho Springs. Producing mines were the Anamosa, Bellevue-Hudson, Silver Mountain, and Tennessee.

*Georgetown (Griffith, Silver Plume) district.*—The Georgetown district in 1916 produced from 20 mines 25,975 tons of ore, yielding $30,396 in gold, 161,945 ounces of silver, 19,662 pounds of copper, 1,635,174 pounds of lead, and 2,524,888 pounds of zinc, with a total value of $592,955, as compared with $308,251 in 1915 and with $142,448 in 1914. The output of ore in 1916 was 9,230 tons less than in 1915. This decrease in quantity of ore was due to the fact that in 1915 a large quantity of the lead-zinc milling ore was drawn from old stopes, whereas in 1916 the lead-zinc ore was of higher grade from new mine operations during the year. The production of gold decreased $8,747 and the yield of copper decreased 6,430 pounds, but the yield of silver increased 73,226 ounces, lead increased 833,302 pounds, and zinc increased 1,058,170 pounds in quantity and $156,462 in value. Practically all the zinc production in Clear Creek County comes from this district.

The Capital Co. operated its mine during the entire year, but operated its 250-ton amalgamation and concentration mill only at various periods. A considerable quantity of lead ore was shipped direct to the smelters from this property. The Onondago Mining Co., operating the Ruler and Comet mines through the Capital adit, shipped ore to the Hudson mill at Idaho Springs. The Onondago Co. also has control of the Colorado Central dump, which is supposed to contain 300,000 tons of low-grade lead-copper-silver ore, and in 1916 the company built a test mill for purposes of experimenting in the treatment of this dump. A large quantity of lead-zinc sulphide ore from various properties was treated at the Graham concentration mill, the product being a lead and zinc concentrate. During the latter part of the year this mill, and also the Mendota-Frostburg mine, was purchased by the Wasatch-Colorado Mining Co., which continued the operation of the mill at increased capacity. Lead-zinc ore from the Smuggler mine was treated at the Graham mill. The Mineral Chief mine and mill were operated during the year. Lessees shipped lead and lead-zinc ore from the Dives-Pelican-Seven-Thirty-Zero group, and the Ballantine experimental mill, installed in the mill at the mouth of the Burleigh tunnel, produced a small quantity of silver-lead concentrate. Other producing mines were the Ashby, Diamond, Mammoth, and Terrible.

*Idaho Springs district.*—In the Idaho Springs district are included the mines about Idaho Springs, including Banner, Cascade, Coral,

Jackson, Lower Fall River, Payne's Bar, Spanish Bar, and Virginia Canyon subdistricts.

In 1916 the Idaho Springs district produced 51,044 tons of ore as compared with 58,647 tons in 1915. Including $250 in placer gold and 5 ounces of placer silver, the production of metals in 1916 was $305,352 in gold, 231,673 ounces of silver, 409,789 pounds of copper, and 2,029,029 pounds of lead, with a total value of $698,604, as compared with $607,665 in 1915. In 1916, of the 51,044 tons of ore mined, 11,175 tons were treated at amalgamation and cyanidation mills having concentration equipment and 33,175 tons were treated at mills for concentration only, a total to both classes of mills of 44,350 tons, yielding 7,989 tons of concentrates (ratio 5.6 to 1). These concentrates and 7,694 tons of crude ore, 15,683 tons in all, were shipped to smelters, and contained all the metals produced by the mines in this district (with the exception of 888.91 ounces of gold, valued at $18,375, and 556 ounces of silver, contained in placer and amalgamation bullion and in cyanide precipitates).

Through the Big Five tunnel the Lake mine continued to be an important producer, the greater quantity of the ore going to various concentration mills in the district and the remainder direct to smelters. The only other important property worked through the Big Five tunnel was the Edgar. Small quantities of ore from the upper levels of the Specie Payment mine were sent to the Black Hawk sampler, but most of the ore was taken out through the Two Brothers tunnel, and was sent to custom mills or to the sampler at Idaho Springs. In Virginia Canyon the producing mines were the Bald Eagle, Bellevue-Champion, Calvin, Comstock, Treasure Vault, and Windsor Castle. Through the Argo (Newhouse) tunnel the Gem Consolidated mines continued to be the principal producing property. A considerable quantity of ore was also mined from the Golden Edge property and shipped to smelters and mills. There was also a small yield from the Sun and Moon group. From mines in Gilpin County being operated from the Argo tunnel an increased quantity of ore was milled at the Argo mill and at other mills in the district. These mines were the Tremont (formerly called Gunnell), Ophir-Burroughs, Pozo-Dyke, and Prize. At the mouth of the Argo tunnel the Argo[1] 20-stamp cyanidation and concentration mill was operated steadily. Experimentation in the use of the froth flotation process, begun in 1915 at this mill, resulted in the complete abandonment of the cyanide process and the installation of the flotation process in June, 1916. The Franklin mine, in Gilson Gulch, continued to produce under the operation of lessees. Ore from the Idaho-Bride mine (worked through the Idaho tunnel) was milled at the reconstructed Mixsell mill. On the south of Clear Creek the Little Mattie mine and amalgamation-

[1] For description see U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 653, 1913; Eng. and Min. Jour., Aug. 30, 1913, pp. 385–389; and Colorado State Bur. Mines Twelfth Bienn. Rept., 1911–12, p. 80, 1913.

See also Roller, A. H., and Curran, H. T., Ore treatment at the Argo mill: Eng. and Min. Jour., p. 1, July 4, 1914.

Eng. and Min. Jour., Aug. 1, 1914, p. 217.

Pearce, J. A., Cyanidation of Clear Creek and Gilpin County sulphides: Min. and Sci. Press, Nov. 28, 1914, pp. 833–837.

Heizer, O. F., Colorado State Bur. Mines Thirteenth Bienn. Rept., 1913–14, pp. 87–90, 1914.

Parmelee, H. C., Cyanidation of low-grade sulphide ores in Colorado: Met. and Chem. Eng., July, 1915, pp. 421–425.

Pearce, J. A., Flotation versus cyanidation: Met. and Chem. Eng., July 15, 1916, pp. 706–708; Flotation tribulations: Min. and Sci. Press, Sept. 16, 1916, pp. 427–430.

concentration mill continued to be operated. Up Fall River the Standard mine and amalgamation-concentration mill were operated for a period.

The mills operated at Idaho Springs in 1916 were the Argo, Combination, Hudson, Jackson, Mixsell, and Newton.

*Montana (Lawson and Dumont) district.*—The Montana district in 1916 from 11 mines produced 545 tons of ore, carrying $17,666 in gold, 7,134 ounces of silver, 30,394 pounds of ore, and 27,464 pounds of lead, with a total value of $31,732, as against $7,544 in 1915. With the exception of a small quantity of ore sent to the Argo mill at Idaho Springs, all the ore went to smelters. An appreciable quantity of high-grade gold-copper ore was shipped from the Albro mine. Other producing mines were Big Chance, Drummond, Heliotrope, Jo Reynolds, Skiddoo, Syndicate, and Thompson. The Little Giant Mining Co., which acquired the Commodore tunnel and other properties on Red Elephant Mountain, made a small shipment of ore during 1916 and is planning to erect a mill at Lawson.

*Trail Creek (Lamartine and Freeland) district.*—The Trail Creek district in 1916 from nine mines produced 12,115 tons of ore, carrying $38,485 in gold, 10,962 ounces of silver, 6,899 pounds of copper, 353,145 pounds of lead, and 37,403 pounds of zinc, with a total value of $76,774, as against $67,274 in 1916.

Lessees on the Lamartine mine shipped lead and lead-zinc ore to the sampler at Idaho Springs and also operated the 50-ton amalgamation and concentration plant on the property. The Oneida 50-ton concentration-flotation mill was operated for a time. The United Freeland Development & Tunnel Co. drove 2,000 feet of crosscuts during the year. Small shipments of ore were also made from the Brazil, Gum Tree, Mendic, Donaldson, Turner, and Toledo.

### CONEJOS AND RIO GRANDE COUNTIES.

*Platoro-Gilmore-Summitville district.*[1]—In the Summitville district, Rio Grande County, nothing but development work seems to have been done.

In Conejos County development work only was done, in the Platoro district.

### COSTILLA COUNTY.

*Grayback district.*[2]—No production was made in this district in 1916.

### CUSTER COUNTY.[3]

From 14 mines in Custer County in 1916 there were sold or treated 2,245 tons of ore, from which were recovered $6,309 in gold; 36,971

[1] For discussion of the geology of the district see Hills, R. C., Ore deposits of the Summit district, Rio Grande County, Colo.: Colorado Sci. Soc. Proc., vol. 1, pp. 20–36, 1883. Raymond, R. W., Mines and mining west of the Rocky Mountains, vol. 10, p. 329, 1875. Emmons, W. H., The enrichment of sulphide ores: U. S. Geol. Survey Bull. 529, p. 226, 1913.

[2] For discussion of geology see Patton, Smith, Butler, and Hoskins, Geology of the Grayback mining district, Costilla County, Colo.: Colorado State Geol. Survey Bull. for 1909. No. 2, 1910.

[3] For discussion of geology see Cross, Whitman, Geology of Silver Cliff and the Rosita Hills, Colo.: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 2, pp. 263–403, 1896; and Emmons, S. F., The mines of Custer County: Idem, pp. 405–472.

ounces of silver, valued at $24,327; 44,004 pounds of copper, valued at $10,825; 123,536 pounds of lead, valued at $8,524; and 10,970 pounds of zinc, valued at $1,470; a total value of $51,455, as compared with $30,340 in 1915. There were increases in all the metals except zinc. With the exception of a nominal quantity of gold-silver bullion from the Bassick mine, all the production from this county was contained in ores shipped direct to smelters.

An appreciable quantity of gold-silver ore was shipped from the dump of the Bassick mine, in the Rosita Hill district. The Terrible[1] mine was idle. A small shipment of lead ore was made from the Marion mine, at Fairview. Producing mines at West Cliff were the Bismuth, Herman, Lady Franklin, Last Quarter, Passiflora, Pioneer, and Ten To One.

## DOLORES COUNTY.

*Mine production in Dolores County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 10 | 14,192 | $11,932 | 127,933 | 1,032,480 | 268,447 | 35,936 | $274,551 |
| 1916 | 13 | 6,398 | 7,426 | 77,280 | 419,500 | 588,333 | 182,306 | 226,497 |
| Increase or decrease, 1916 | +3 | −7,794 | −4,506 | −50,653 | −612,980 | +319,886 | +146,370 | −48,054 |

*Lone Cone (Dunton) district.*—A small shipment of ore was made from the Emma mine.

*Pioneer (Rico) district.*[2]—This district in 1916 produced 6,370 tons of ore, yielding $5,557 in gold, 71,578 ounces of silver, 419,500 pounds of copper, 587,695 pounds of lead, and 182,306 pounds of zinc, with a total value of $220,832, as compared with $271,454 in 1915. The larger part of the ore shipped from this district in 1916 was copper ore, which was sent to smelters in Utah and also to Durango, Colo. There was an increased quantity of lead-zinc ore shipped, and also of zinc ore. Some iron ore (for its iron content only) was shipped to Vanadium, Colo., for use in the treatment of vanadium ores.[3]

The Rico Wellington group was the principal producing property. The public report of this company states that the output for 1916 was 4,989 tons of copper and lead ore, with a net value of $19.09 a ton; and 292 tons of iron sulphide ore, with a net value of $4 a ton. The total net value from all production was $102,202. There was 7,062 feet of development work done.

Lessees on the Rico Mining Co.'s group also shipped a considerable quantity of lead and lead-zinc sulphide ore. Lead sulphide ore was

[1] For discussion of geology see Hunter, J. F., Some cerusite deposits in Custer County, Colo.: U. S. Geol. Survey Bull. 580, pp. 25–37, 1914.

[2] For discussion of geology see Cross, Whitman, and Spencer, A. C., Geology of the Rico Mountains, Colo.: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 7–165, 1900; and Ransome, F. L., The ore deposits of the Rico Mountains, Colo.: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pp. 229–398, 1901.

[3] For discussion of treatment of vanadium ores see Moore, R. B., and Kithil, K. L., A preliminary report on uranium and vanadium: U. S. Bur. Mines Bull. 70, p. 74, 1914.

shipped from the Lucky Boy group by the Rico Consolidated Mining Co. Other producing mines were the Argentine, Aztec, Carbonate, Forest Payroll, Iron Cap, and Nora Lilly.

## DOUGLAS COUNTY.

There seems to have been no placer gold recovered by sluicing in Newlins Gulch, near Parker, and other localities of Cherry Creek in Douglas County, from which for many years there has been a nominal quantity produced each year.

## EAGLE COUNTY.

*Mine production in Eagle County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine oz.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 25 | 74,197 | $95,426 | 177,550 | 60,086 | 1,394,043 | 11,141,750 | $1,643,056 |
| 1916 | 32 | 105,149 | [a] 96,036 | 222,126 | 112,610 | 1,517,362 | 28,438,052 | 4,185,294 |
| Increase, 1916 | +7 | +30,952 | +610 | +44,576 | +52,524 | +123,319 | +17,296,302 | +2,542,238 |

[a] Includes small placer production.

The total value of the output of Eagle County in 1915 was by far the largest since the discovery of gold at Red Cliff in 1879, but the total value was two and one-half times as great in 1916 as in 1915. The greater part of the production of Eagle County came from the Battle Mountain (Red Cliff) district, although there was a considerably increased yield of silver from the Brush Creek district, also several small lots of ore from the Edwards district and one small lot of copper ore from the Fulford district. The value of the output of zinc for 1916 was $3,810,699, an increase of $2,429,122. The county continued to maintain second place to Lake County in the yield of zinc.

*Battle Mountain (Red Cliff)*[1] *district.*—The Red Cliff district in 1916 produced 103,799 tons of ore, yielding $95,378 in gold, 113,120 ounces of silver, 110,732 pounds of copper, 1,515,580 pounds of lead, and 28,438,052 pounds of zinc, the total value being $4,112,325, as compared with $1,630,781 in 1915. The Iron Mask mill was continuously operated on lead-zinc ore from the Iron Mask mine, with product in zinc, lead, and iron manganese concentrates. In addition, a considerable quantity of zinc carbonate ore was shipped from the Iron Mask mine and smaller quantities of zinc carbonate ore from other properties in the district. A very large quantity of zinc-lead sulphide ores was shipped from the Black Iron and Ground Hog mines to various mills and smelters. Other producing mines of importance were the Ben Butler, Foster-Combination, Mabel, Pursey Chester, Star of the West, Tip-Top, Tram, and Wyoming Valley.

[1] For discussion of geology see Means, A. H., Geology and ore deposits of Red Cliff, Colo.: Econ. Geology, vol. 10, No. 1, pp. 1–27, January, 1915; also Argall, Philip, Siderite and sulphides in Leadville ore deposits: Min. and Sci. Press, July 11, 1914, p. 52 (siderite at Red Cliff.)

*Eagle or Brush Creek district.*—An increased quantity of high-grade silver ore was shipped from the Lady Belle mine.

*Edwards district.*—A small quantity of gold bullion and a small lot of gold ore were shipped from the J. D. mine, and a small lot of lead was shipped from the Mandy May property.

*Fulford district.*—A small lot of copper ore was shipped from the Calientes mine.

*McDonald district.*—Sluicing operations on Grand River near Burns resulted in the yield of a small quantity of placer gold.

### EL PASO COUNTY.

*Blair Athol district.*—No work was done on the copper deposits in sandstone at Blair Athol, about 6 miles north of Colorado City, from which shipments had been made in 1913 and 1914.

### FREMONT COUNTY.

From 11 mines in Fremont County in 1916 there were sold or treated 1,734 tons of ore yielding $786 in gold, 4,529 ounces of silver, 101,041 pounds of copper, and 31,710 pounds of lead, with a total value of $30,810, as compared with $54,303 in 1915.

Several shipments of copper ore were made from the Badger Creek district, near Howard. Producing mines were the Arizona, Calumet, Good Friday, and Washington. Copper ore was also shipped from the Gumaer and Sure Shot mines, near Cotopaxi, and from the Currant Creek district, near Parkdale, copper ore was shipped from the Copper Girl and Green Mountain mines. A small lot of copper ore was shipped from the Windy Point mine in the Grape Creek district.

### GARFIELD COUNTY.

The Gray Eagle mine, near New Castle, was idle in 1916.

### GILPIN COUNTY.[1]

*Mine production in Gilpin County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 90 | 54,052 | $562,878 | 125,665 | 476,383 | 591,127 | 11,000 | $739,104 |
| 1916 | 87 | 38,913 | 453,259 | 126,553 | 557,317 | 521,334 | ..... | 709,603 |
| Increase or decrease, 1916 | −3 | −15,139 | −109,619 | +888 | +80,934 | −69,793 | −11,000 | −29,501 |

The quantity of ore sold or treated in Gilpin County in 1916 showed a very appreciable decrease, which resulted in a decrease of $109,619 in gold but a small increase in silver and a small decrease in

[1] Bastin, E. S., Economic geology of Gilpin County and adjacent parts of Clear Creek and Boulder counties, Colo.: U. S. Geol. Survey Prof. Paper 94, 1916.

lead. With the higher price prevailing for the metals, however, the total value of the production showed a decrease of only 4 per cent. The principal decrease in ore was in the class sent to amalgamation and concentration mills in Gilpin County, with a consequent heavy decrease in gold-silver bullion produced. The quantity of ore sent from Gilpin County to mills for concentration only (both in Gilpin County and at Idaho Springs as well) showed an increase, but the quantity of concentrates produced from both classes of mills decreased appreciably, and their contents showed a decrease for gold, a small increase for silver, a small increase for copper, and a small decrease for lead. The crude ore shipped direct to smelters showed a slight increase in quantity, but the content in gold and lead decreased, and the content in silver and copper increased slightly. Operating mills, including custom amalgamation and concentration mills, in 1916 were the American Metals Producing Co. (old Rocky Mountain concentrator), Carr (Most), Eureka, Iron City, Polar Star, Saratoga, Smith, Two-Forty, and U. P. R. The Iron City concentration mill was operated continuously in 1916, but the Polar Star was operated only intermittently, and the U. P. R. for only part of one month. The Saratoga mill, a small plant on the Saratoga dump, was operated for a time only, as was the Two-Forty mill, a flotation plant. The Smith mill was operated continuously until November, 1916, when it was burned. The Eureka mill was operated almost continuously during the year. Almost all the ore of Gilpin County is dry siliceous, but some of the ore (and an increased quantity in 1916) carries copper above 2½ per cent, and a small quantity contains lead above 4½ per cent. Concentrating ore in 1916 made practically all dry concentrates, although some lead concentrates and some copper concentrates were produced. A large part of the output of Gilpin County, particularly from the Gunnell mine (Tremont) was mined from the Argo tunnel level and treated at the Argo mill at Idaho Springs, and ore from the Dyke mine and Ophir-Burroughs mine from the tunnel level was shipped to the sampler and to mills at Idaho Springs.

*Southern districts* (*Central City*, *Black Hawk*, *Nevadaville*, *Russell Gulch*).—The old districts of the main area of Gilpin County are so indefinite that separation of output by districts has been abandoned.

In the near vicinity of Central City producing mines were the Corydon and Troublesome.

Producing mines in the Enterprise district were the Brack Hollow and Coaley.

Producing mines in the district embracing Gunnell Hill and Eureka and Prosser gulches were the Boodle, Eureka, and Gunnell (Tremont group). All the ore from the Tremont group was trammed through the Argo tunnel to Idaho Springs.

Producing mines in the district embracing the town of Black Hawk, and Gregory, Bobtail, and Bates hill, were the Bates, Centennial, Colorado-Carr, Fisk, Gregory, Gilpin-Orion, Hamlet, Homer, Nemaha, Running Lode, and Senator.

Producing mines in the district embracing Illinois and Leavenworth gulches and the east portion of Quartz hill were the Barnes, German-Belcher, Ingalls, and Wood.

Producing mines in the Lake Gulch district were the Pittsburg, Pittsburg Extension, Vivian-Notoway, and West Notoway. This was one of the principal producing districts in the county, the yield being derived chiefly from the Pittsburg mine, from which a considerable quantity of high-grade copper-gold-silver ore was shipped.

In the vicinity of Nevadaville among the producing mines were the Belden, Columbia, Ophir-Burroughs, Pozo-Dyke, and Prize. The Dyke, Ophir-Burroughs, and Prize mines were worked from the Argo tunnel level and the ore was shipped to Idaho Springs, but the contents were credited to Gilpin County.

In the Quartz Valley district producing mines were the Buckeye, Gold Cup, and Hayseed Tunnel.

In the Russell Gulch district among producing mines were the Denbigh, Druid, East Notoway, Frontenac, Hampton, Lillian, Old Town, Pewabic, Powers, Richardson, Saratoga, Silver Dollar, Star of the West, Subtreasury, and Two-Forty.

*Northern districts.*—The outlying districts in Gilpin County are the Vermilion district, 4 miles northwest of Central City; Pine district, 7 miles northwest of Central City; Independence and Union districts, 9 miles north of Central City, embracing Perigo and Rollinsville, Lump Gulch, and Moon Gulch sections; Phoenix district, along the north edge of the county, near the Boulder County line; Silver Lake district, 5 miles north of Central City; and Hawkeye district, 7 miles north of Central City and 4 miles east of Apex.

The principal mine in this district in 1916 was the Smuggler, near Rollinsville, the ore being treated in the amalgamation-concentration mill on the property. At the Evergreen mine, at Apex, a flotation plant was installed and a test run was made during the year. A test run was also made at the amalgamation-concentration mill on the Seabird property, and a small lot of ore from the Golden Sheaf mine was concentrated. Silver-lead ore from the Alaska mine, in the Hawkeye district, was shipped to Black Hawk. The mill on the Penobscot property was operated for a short period. A "clean-up" was made at the Perigo mill and at the dismantled Golden Flint mill.

## GRAND COUNTY.

A small lot of copper ore was shipped from Kremmling, and a small lot of silver ore was shipped from the Williams Forks district.

## GUNNISON COUNTY.

*Mine production in Gunnison County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 15 | 6,446 | $60,197 | 24,892 | 9,091 | 190,000 | 1,750,944 | $300,455 |
| 1916 | 18 | 10,419 | a31,553 | a29,023 | 84,679 | 313,217 | 1,964,873 | 356,386 |
| Increase or decrease, 1916 | +3 | +3,973 | −28,644 | +4,131 | +75,588 | +123,217 | +213,929 | +55,931 |

a Includes placer production.

*Box Canyon district* (*Wuanita Hot Springs*).[1]—At the Brant Independent mine, opened by a 1,800-foot adit, no work was done in 1916, but early in 1917 a contract was let for 500 feet of tunneling. The power for operations at this property is supplied by the company's own hydroelectric power plant completed in 1914. Assessment work was done at the Mascot tunnel.

*Cebolla district* (*Vulcan, Domingo*).[2]—In this old district, revived in 1915, there was a considerable quantity of copper ore shipped from the Anaconda mine during the early part of 1916. At the Good Hope mine, opened by a 720-foot vertical shaft, unwatered to the 400-foot level in 1915, a large quantity of gold-silver ore, containing some copper, was shipped to smelters, from January to October. During the year a small copper matting furnace was installed and a small quantity of copper matte was shipped. Operations were apparently not successful as the property was closed at the end of the year.

*Cochetopa district* (*Sillsville*).[3]—No production was made in 1916 in this district.

*Elk Mountain district* (*Gothic and Crested Butte*).[4]—From the Doctor mine on Spring Creek, opened by a 550-foot adit, of which 250 feet was driven in 1916, zinc carbonate ore was shipped continuously throughout the year. A car of lead ore was shipped from the Cascara-Yankee Blade property.

*Gold Brick district* (*Ohio City*).[5]—At the amalgamation-concentration mill at the Belzora-Bassick mine a test run was made on ore taken out in development work. This property is opened by 6,100 feet of adit and other openings, of which 870 feet was driven in 1916. Very little work was done at the Carter mine during the year 1916, although this property was an important producer in 1915. The various claims of the property are opened by several vertical shafts from 50 to 200 feet deep, one 1,135-foot vertical 4-compartment upraise, 6,771 feet of tunnels, and several thousand feet of drifts. There is an amalgamation-concentration mill[6] on the property. Several small lots of ore were shipped from other properties in this district. The Gold Links amalgamation-concentration mill was idle.

*Quartz Creek district* (*Pitkin*).[3]—Several lots of gold-silver ore were shipped during the year.

*Rock Creek district* (*Marble*).[6]—There was a small shipment of copper ore from the Copper Consolidated mine. Considerable development work was done at the Sheep Mountain tunnel, and development work was done at the Lead King mine.

*Tin Cup district.*[3]—The 40-ton concentration mill at the Forest Hill mine was operated for a time, the product being lead and zinc concentrates. The Tin Cup placer on Willow Creek, on which a

[1] For discussion of geology see Hill, J. M., Notes on the economic geology of southeastern Gunnison County, Colo.: U. S. Geol. Survey Bull. 380, pp. 21–40, 1909.

[2] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 380, p. 273, 1909; U. S. Geol. Survey Bull. 427, p. 150, 1910. Leith, C. K., Iron ores of the western United States and British Columbia: U. S. Geol. Survey Bull. 285, p. 197, 1906.

[3] See Hill, J. M., op. cit.

[4] Harder, E. C., op. cit., pp. 188–198. Emmons, S. F., Cross, Whitman, and Eldridge, G. H., U. S. Geol. Survey Geol. Atlas, Anthracite-Crested Butte folio (No. 9), 1894.

[5] For description see Carter, C. M., Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, p. 96, 1914.

[6] Emmons, S. F., Cross, Whitman, and Eldridge, G. H., U. S. Geol. Survey, Geol. Atlas, Anthracite-Crested Butte folio (No. 9), 1894. Covers merely extreme source of Rock Creek, and geology discussed only in general way.

dredge was operated in 1914 but was idle in 1915, was again operated in 1916. There was a small quantity of placer gold recovered from the Little Gem placer, 15 miles north of Tin Cup at the end of Illinois Creek.

*Tomichi district (Whitepine).*[1]—At the Akron group, Erie group, and Ensign group, opened by a long adit, the Akron Mining Co. operated continuously during the year on development work, from which a considerable quantity of lead-zinc ore was mined and milled at the 60-ton concentration plant on the property. Several cars of lead zinc ore were shipped from the Morning Star mine. From the Alice mine a small quantity of lead ore was milled at the Akron mill. Several cars of copper ore were shipped from the Spar Copper group, and a car of zinc carbonate and one of lead ore were shipped from the Victor mine. Several cars of lead ore were shipped from the Maid of Erin.

## HINSDALE COUNTY.[2]

Hinsdale County produced in 1916 from 18 mines 377 tons of ore, yielding $1,346 in gold; 10,030 ounces of silver, valued at $6,600; 16,248 ounces of copper, valued at $3,997; 75,638 pounds of lead, valued at $5,219; and 12,575 pounds of zinc, valued at $1,685, a total value of $18,847, against $19,718 in 1915.

*Galena district.*—Only occasional small lots and cars were shipped during the year from the Big Casino, Excelsior, Good Luck, Frank Hough, Independence, Ocean Wave, Oriental, and Western Chief.

*Lake district.*—Several cars of ore were shipped from the Cora and Gladiator mines. Small lots of ore were shipped from the Cleveland, Grove, Pearl-Ruby, and Pelican. The Colorado-Utah Co., which built during 1915–16 a concentration-flotation mill for the treatment of the dump of the Golden Fleece mine, made a small test run in 1916.

*Burrows Park district.*—Some assessment work was done in this district and the old Tobasco mill is reported to have been purchased for the purpose of dismantlement and moving to a new site for the treatment of ore from the Copper Boy mine.

## JACKSON COUNTY.

*Pearl district.*[3]—Resumption of work at the Wolverine mine resulted in the shipment of several cars of silver-copper ore during 1916. Shipments were continued during 1917.

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[1] For discussion of geology see Crawford, R. D., Geology and ore deposits of the Monarch and Tomichi districts, Colo.: Colorado Geol. Survey Bull. 4, 1913. Hill, J. M., op. cit.; Harder, E. C., op. cit.; Leith, C. K., op. cit.

[2] For discussion of geology see Irving, J. D., Ore deposits in the vicinity of Lake City, Colo.: U. S. Geol. Survey Bull. 260, pp. 78–84, 1905; Ore deposits of the Ouray district, Colo.: U. S. Geol. Survey Bull. 260, pp. 50–77, 1905. Irving, J. D., and Bancroft, Howland, Geology and ore deposits near Lake City, Colo.: U. S. Geol. Survey Bull. 478, 128 pp., 1911. Larsen, E. S., The economic geology of Carson Camp, Hinsdale County, Colo.: U. S. Geol. Survey Bull. 470, pp. 30–38, 1911. Woolsey, L. H., Lake Fork extension of the Silverton mining area, Colo.: U. S. Geol. Survey Bull. 315, pp. 26–30, 1907.

[3] Spencer, A. C., Reconnaissance examination of the copper deposits at Pearl, Colo.: U. S. Geol. Survey Bull. 213, pp. 163–169, 1903.

## LAKE COUNTY.

### PRODUCTION.

*Mine production in Lake County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Placer. | Deep. | | | | | |
| | | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 101 | 481,620 | $69,009 | $2,177,143 | a2,571,002 | 1,803,423 | 20,957,404 | 72,493,178 | $13,839,401 |
| 1916 | 90 | 477,240 | 119,169 | 1,601,271 | a2,931,281 | 2,621,675 | 21,719,392 | 76,785,567 | 16,082,059 |
| Increase or decrease, 1916 | −5 | −4,380 | +50,160 | −575,872 | +360,279 | +818,252 | +761,988 | +4,292,389 | +2,242,658 |

a Includes placer production.

Lake County in 1916 produced gold, silver, copper, lead, and zinc, with a total value of $16,082,059, the largest in the history of the county. This production was $3,909,998 larger than the total value of gold and silver produced in the Cripple Creek district during 1916. During the period 1896–1916 Lake County has surpassed Teller County (Cripple Creek) three times—in 1912, 1915, and 1916. Lake County in 1916 also shipped a greatly increased quantity of manganese ore for use in the manufacture of spiegeleisen, for which no credit is given in this report, but is given in the manganese report. The quantity of ore from Lake County, however, was not equal to that of 1915, the decrease being most apparent in the quantity of siliceous oxidized ores. This county was again first in the production of silver, copper, lead, and zinc; in the production of gold it again took third place, following after Teller, and San Miguel.

Of the State total, Lake County produced 9 per cent of the gold, 38 per cent of the silver, about 30 per cent of the copper, 31 per cent of the lead, and 57 per cent of the zinc.

The Derry Ranch dredge, on Arkansas River, 12 miles below Leadville, which was operated for the first time in 1915, and had a yield of $69,009 in gold and 1,059 ounces of silver, produced $120,000 of placer gold and silver in 1916. This 1915–1916 placer production is the first for Lake County since the early placer mining in California Gulch following the discovery of gold in that district.

Lake County includes the Leadville, St. Kevin, Sugar Loaf, Twin Lakes, Lackawanna Gulch, Big English Gulch, Weston Pass, Wortman, and Arkansas River placer districts.

### LEADVILLE (CALIFORNIA) DISTRICT.[1]

#### GENERAL FEATURES.

Of a total of 477,240 tons of ore mined in 1916 in this county, 460,318 tons were from the Leadville district. The yield was $1,470,557 in gold, 2,783,570 ounces of silver, 2,610,394 pounds of

[1] For discussion of geology see Emmons, S. F., Geology and mining industry of Leadville, Colo.: U. S. Geol. Survey Mon. 12, 1886; Emmons, S. F., and Irving, J. D., The Downtown district of Leadville, Colo.: U. S. Geol. Survey Bull. 320, 1907. Argall, Philip, Siderite and sulphides in Leadville ore deposits: Min. and Sci. Press, July 11 and 25, 1914, pp. 50–54, 128–135; Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 380, p. 273, 1909; U. S. Geol. Survey Bull. 427, pp. 137–143, 1910.

copper, 21,510,682 pounds of lead, and 76,008,276[1] pounds of zinc, with a total value of $15,613,649, out of a county total production of $16,082,059. As compared with 1915, this output shows a decrease of 10,490 tons of ore, a decrease of $533,309 in gold, an increase of 394,199 ounces of silver, an increase of 828,159 pounds of copper, an increase of 702,275 pounds of lead, and an increase of 3,583,403 pounds of zinc.

The output of zinc carbonate ore increased from 82,592 tons of 22.48 per cent zinc in 1915 to 85,513 tons of 21.52 per cent zinc in 1916. The zinc sulphide ores sold or treated at Leadville increased from 136,555 tons of 22.09 per cent in 1915 to 147,295 tons of 21.69 per cent in 1916. The production of iron pyrites showed hardly any change in quantity, but contained more gold than in 1915, and 479,532 ounces of silver more than in 1915, and also considerably more copper, but less lead. Iron fluxing and iron-manganese ore used for fluxing purposes made little change. (There was, however, again a heavy increase in shipments of iron-manganese ore for use in the manufacture of spiegeleisen.) The quantity of siliceous oxide ores decreased to less than one-third of the quantity in 1915, and the content of gold in this ore to approximately one-seventh of that in 1915, and the content of silver was little more than one-half of the yield in 1915. Copper oxidized ores increased from 3,359 tons in 1915 to 8,520 tons in 1916, but the copper ores in 1915 averaged 6.33 per cent copper, whereas these ores averaged 3.75 per cent in 1916.

*Classification of Leadville ores in 1916.*

| Character. | Quantity. | Percentage. |
|---|---|---|
| Sulphide: | *Short tons.* | |
| Zinc-iron-lead (zinc blende: pyrite and galena) | 147,295 | 32 |
| Iron (pyrite with a little gold, silver, copper, and lead, and some zinc blende)[a] | 161,096 | 35 |
| Iron (pyrite with a little gold, silver, copper, and lead over 4½ per cent dry lead, with some zinc blende)[a] | 2,208 | |
| Total sulphide | 310,599 | 67 |
| Oxide: | | |
| Lead | 19,716 | 4 |
| Copper[b] | 8,520 | 2 |
| Iron flux | 3,879 | 1 |
| Iron-manganese flux | 18,215 | 4 |
| Siliceous[c] | 13,876 | 3 |
| Zinc | 85,513 | 19 |
| Total oxide | 149,719 | 33 |
| Grand total | 460,318 | 100 |

[a] The greater part of the iron pyrite ore carries iron in excess of silica and also high silver but low gold content; a large quantity (particularly in 1916) of iron pyrite ore (from Breece Hill mines) carries silica in great excess over iron and high gold but low silver content. Some of the iron pyrite ore approaches the zinc-iron-lead classification (when zinc market gives higher returns for sale as lead-zinc sulphide than as lead sulphide to lead smelters) and vice versa.

[b] The high price of copper during 1916 stimulated the sale of this class of ore.

[c] All the siliceous oxide ore is also dry. The greater part of this siliceous oxide ore carries a heavy excess of silica over iron; a small part carries iron and silica in equal quantities. Metallic gold, in quantity 1,285.56 fine ounces, valued at $26,575, and 310 ounces of silver came from less than a ton of ore, from siliceous oxide and sulphide ore bodies.

[1] The actual production of zinc from ore produced from the mines during 1916 was approximately 13,000,000 pounds less than the production credited to Leadville, there being a large tonnage of sulphide ore and dump material treated in 1916, but removed from Leadville in 1905 and previously and never before recorded in the production of Leadville.

*Classification of Leadville Ores in 1916*—Continued.

| Character. | Quantity. | Recovered contents. Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Sulphide: | | | | | | |
| Zinc-iron-lead | 147,295 | [b] 2,031.07 | [a] 340,463 | [a] 1,835 | [a] 12,922,633 | (b) |
| Iron pyrites | 161,096 | 54,574.15 | 2,039,723 | 1,688,230 | 3,154,198 | ..... |
| Lead sulphide | 2,208 | 570.77 | 63,840 | 3,779 | 813,562 | ..... |
| Oxide: | | | | | | |
| Lead | 19,716 | 3,483.43 | 114,256 | 27,585 | 3,767,487 | ..... |
| Copper | 8,520 | 4,217.54 | 29,573 | 639,672 | 86,085 | ..... |
| Iron flux | 3,879 | 333.01 | 2,982 | ..... | ..... | ..... |
| Iron-manganese flux | 18,215 | 28.03 | 110,743 | ..... | 245,522 | ..... |
| Siliceous | 13,876 | 4,614.64 | 81,680 | 249,293 | 521,195 | ..... |
| Zinc | 85,513 | ..... | ..... | ..... | ..... | (b) |
| Metallics (sulphide and oxide) | ..... | 1,285.56 | 310 | ..... | ..... | ..... |
| | 460,318 | 71,138.20 | 2,783,570 | 2,610,394 | 21,510,682 | 76,008,276 |
| Dry, iron, and siliceous ores [c] | 197,066 | 60,835.39 | 2,235,438 | 1,937,523 | 3,920,915 | ..... |
| Copper ores [d] | 8,520 | 4,217.54 | 29,573 | 639,672 | 86,085 | ..... |
| Lead ores [e] | 21,924 | 4,054.20 | 178,096 | 31,364 | 4,581,049 | ..... |
| Zinc ores [f] | 85,513 | ..... | ..... | ..... | ..... | 30,174,903 |
| Lead-zinc ores [g] | 147,295 | 2,031.07 | 340,463 | 1,835 | 12,922,633 | 45,833,373 |
| | 460,318 | 71,138.20 | 2,783,570 | 2,610,394 | 21,510,682 | 76,008,276 |

| Character. | Average recovery. Gold. | Silver. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|
| | *Ounces per ton.* | *Ounces per ton.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Sulphide: | | | | | |
| Zinc-iron-lead | [h] 0.028 | [h] 5.17 | (h) | [h] 8.37 | [h] 20.96 |
| Iron pyrites | .339 | 12.66 | 0.52 | .98 | ..... |
| Lead sulphide | .259 | 28.91 | ..... | 18.42 | ..... |
| Oxide: | | | | | |
| Lead | .177 | 5.80 | .07 | 9.55 | ..... |
| Copper | .495 | 3.47 | 3.75 | .51 | ..... |
| Iron flux | .086 | .77 | ..... | ..... | ..... |
| Iron-manganese flux | .002 | 6.08 | ..... | .67 | ..... |
| Siliceous | .333 | 5.81 | .90 | 1.88 | ..... |
| Zinc | ..... | ..... | ..... | ..... | [i] 21.52 |
| Metallics (sulphide and oxide) | ..... | ..... | ..... | ..... | ..... |

[a] Recovered as lead and iron concentrates and in zinc residues.
[b] Zinc in terms of recovered spelter and as zinc in zinc oxide.
[c] Includes siliceous oxide, iron, and iron manganese (silver), largest part of iron pyrite. Smelting ores. Also includes metallics.
[d] Sulphide and oxide. Smelting ores.
[e] Sulphide and oxide lead ores. Smelting ores.
[f] Zinc carbonate only. To smelters.
[g] Sulphides. Greater part to concentration mills.
[h] Average assay of greater part of original ore for which data was available. (Lead wet assay.) Average assay of all zinc sulphide was 21.69 per cent zinc.
[i] Average assay of original content; no deductions for loss in smelting. All to zinc plants.

The course of treatment of Leadville ores from mine mouth to market was shown graphically in Mineral Resources for 1911, Part I, page 547, figure 1. With the exception of the quantity of ore, the flow sheet for 1911 applies for 1916 in nearly all of the details.

During 1916 the 50-ton zinc-oxide plant was continuously operated on low-grade zinc-carbonate ores. The Leadville District concentration mill was also operated steadily as a concentration-flotation plant on low-grade sulphide ores from various Leadville mines and dumps and also from mines in Chaffee and Summit counties.

The water in the Downtown mines was completely lowered during the year, and on November 1, 1916, shipments of manganese ore to the Pueblo Steel Works were commenced, and later shipments of zinc carbonate were made. The United States Smelting, Refining & Mining Co. succeeded in unwatering its properties on Fryer Hill and shipped zinc carbonate and iron sulphide ores.

MINES REVIEW.

*California Gulch, Iron Hill, and Breece Hill mines as opened by the Yak Tunnel.*—The Yak tunnel starts in California Gulch and unwaters and develops a great number of mines along its course through Iron and Breece hills toward the Mosquito Range. Of the mines operated by the Yak Co. itself, the bulk of the ore continues to come from the property of the Cord Mining Co. (Minnie Lee claim). Besides the operations of the Yak Co. and its auxiliary company, the Leadville Exploration & Mining Co., there were shipments of ore by lessees from other mines controlled and developed by the Yak Co. Other important mines from which ore was shipped were the Diamond, Dolly B., Fortune, Polaris, Resurrection, Rubie, Sierra Nevada, South Cord, Tenderfoot, Vega, and White Cap. The bulk of the ore was iron sulphide, which was shipped to lead smelters in Colorado, but these properties also shipped ore of other classifications. Much iron pyrite ore, chiefly valuable for its sulphur content, but also carrying considerable silver and some lead and zinc, was shipped to plants for the manufacture of sulphuric acid, the roasted residue finally reaching lead plants. The magnetic separation plant at the mouth of the Yak Tunnel remained idle.

*Iron Hill.*—From the Tucson and Moyer mines and from leases on the property of the Iron Silver Mining Co. were shipped large quantities of various classes of ore containing 1,355 ounces of gold, 336,277 ounces of silver, 2,401,089 pounds of lead, 76,500 pounds of copper, and 12,964,342 pounds of zinc.

Lead-zinc sulphide ore was shipped from the A Y and Minnie mine; during part of the year lead-zinc sulphide ore and pyritic ore were shipped from the Colonel Sellers mine; and throughout the year large quantities of lead-iron and lead-zinc sulphides were shipped from the Louisville mine. Pyritic ores were shipped from the Adelaide and from the Humboldt mines on North Iron Hill.

*Breece Hill.*—Breece Hill and South Evans Gulch embrace the chief mines of the gold belt.

Lessees on the property of the Ibex Mining Co. continued to ship large quantities of various grades of ore, as well as considerable metallic gold. Siliceous oxide ore and pyritic ore were shipped from the Nonie mine. Metallic gold was sent to the mint and lead oxidized and pyritic ore were shipped from the St. Louis tunnel to smelters. Hematite fluxing ore and siliceous ore continued to be shipped from the Breece mine; siliceous oxide ore from the Big Four, Big Six, President, and Robert Burns; and zinc carbonate from the Eliza, Elk, and Rattling Jack.

*South Evans Gulch and Little Ellen Hill.*—The ores of this vicinity carry an appreciable gold and silver content. From the New Monarch mines there were shipped considerable quantities of siliceous

sulphide, lead oxidized, lead sulphide, and lead-zinc sulphide ores. Iron manganese fluxing ore, siliceous sulphide ore, lead sulphide ore, lead oxidized ore, and pyritic ore were shipped from the Valley mine. Lead oxidized and zinc carbonate ores were shipped from the Little Ellen mine.

*Carbonate Hill.*—The bulk of the zinc carbonate shipments from Leadville came from mines on Carbonate Hill. Large shipments continued to be made from the Big Chief, Castle View, Maid of Erin, Wolftone, and other mines of the Western Mining Co. through the Wolftone shaft, and from the Star Consolidated Mines Co. Iron-manganese ore in quantity from the Star mines was shipped both to lead plants for fluxing purposes and to the steel plant at Pueblo for the manufacture of spiegeleisen. For the first time in several years considerable lead-zinc sulphide ore was shipped from the Western Mining Co.'s properties, owing to the lowering of the water to the sulphide zone. Early in 1917 large quantities of lead-zinc sulphide ore were again shipped from this property.

*Fryer Hill.*—Iron-manganese ore was shipped from the All Right, Dunkin, Denver City, Matchless, Seneca, and other mines; iron-manganese, lead oxidized, and zinc carbonate ores from the Little Chief; lead-zinc sulphide ores were shipped from the Result and Forest City mines through the McCormick shaft; lead-zinc sulphide ores were shipped from the Gambetta mine; zinc carbonate ores from the Chrysolite mine; and zinc carbonate and iron-manganese ores from the Robert E. Lee mine. At the Leadville unit of the United States Smelting, Refining & Mining Co. unwatering was completed and several of the properties were cleaned out and retimbered and zinc carbonate and silver-iron sulphide ores were shipped.

*Printer Boy Hill.*—Siliceous oxidized, lead oxidized, and zinc carbonate ores were shipped from the Lilian mine and siliceous oxidized ore from the Reveille.

*Rock Hill.*—Lead oxidized ore, carrying considerable iron and manganese, was shipped from the La Plata mines and iron manganese ore from the Nisi Prius.

*Iowa Gulch.*—Lead sulphide ore from the First National and siliceous ore from the Doris mine were shipped.

*Downtown district.*—The Penrose shaft was unwatered to a depth of 900 feet on June 13, 1916, and on November 1, 1916, shipments of iron-manganese and zinc carbonate ores were commenced.

### OTHER DISTRICTS.

*St. Kevin-Sugar Loaf-Independence district.*—From the early days of Lake County there has been a production from the district lying along the base of the Sawatch Range, including St. Kevin and Sugar Loaf mountains. In 1916 siliceous oxidized and sulphide silver-gold ores were shipped from the Dinero, siliceous oxidized ore from the Sugar Loaf Consolidated Co., siliceous ore from the Amity and Anchor, and sulphide ore from the Jimmy Swisher. From the Carleton-Griffin mine were shipped silver oxidized, gold-silver sulphide, and silver-lead-zinc sulphide ores, the latter in considerable quantity.

*Twin Lakes and Lackawanna Gulch districts.*—A small shipment of gold-silver-copper ore was shipped by the Fidelity Co. The Mount

Champion mine and 100-ton amalgamation and concentration mill,[1] in Lackawanna Gulch, continued to be operated.

*Weston Pass district.*—During the first six months of the year shipments of zinc and lead carbonate ores were made from the Ruby, Cincinnati, and Colin Campbell mines, at the head of Weston Gulch.

*Wortman district.*—The Denver Mining & Milling Co., operating the Burma (or John Reed) mines, shipped a considerable quantity of lead-zinc ore to various plants and operated its concentration mill for a short period.

*Arkansas Valley dredge district.*—At the mouth of Box Creek, 12 miles from Leadville, a dredge installed during the summer of 1915 and operated for 70 days during that year, was operated from April 27, 1916, to December 8, 1916. The dredge handled 500,000 cubic yards and recovered $120,000. The buckets on this dredge have a capacity of 6 cubic feet.[2]

## LA PLATA COUNTY.

*Mine production in La Plata County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine oz.* | *Pounds.* | *Pounds.* | |
| 1915 | 25 | 2,952 | $71,530 | 46,369 | 4,114 | 23,362 | $96,857 |
| 1916 | 36 | 1,602 | 31,653 | 29,187 | 12,024 | 6,551 | 54,268 |
| Increase or decrease, 1916 | +11 | −1,350 | −39,877 | −17,182 | +7,910 | −16,811 | −42,589 |

With the exception of the output of some gold bars and retorts from high-grade specimens, all the ore produced in this county was shipped direct to smelters.

*California*[3] *(La Plata) district.*—The mines of this district are located in the La Plata Mountains, in the drainage basin of La Plata River, centering around the town of La Plata, 10 miles from Hesperus, the shipping point on the Rio Grande Southern Railroad.

The May Day mine was idle. The principal producing mines were the Bay City, Little Nona, and Valley View. Other producing mines of some importance were Bessie, Chief, Durango Girl, Golden Rose, Mountain Lode, and Tomahawk.

The west slope of the west ridge of the La Plata Mountains, in Montezuma County, is a continuation of the La Plata district, from which a car of gold-silver ore was shipped from the Gold Dollar mine.

*Cave Basin district.*—This district, from which a small yield was made in 1913, is located in the San Juan National Forest, about 20 miles north and east of Bayfield, in La Plata County, near the La Plata-Hinsdale County line between Vallecito and Pine rivers.

A small lot of copper-silver ore was shipped in 1916 from the Mary Murphy mine.

[1] For description see Becker, J. A., Colorado State Bur. Mines Thirteenth Bienn. Rept., 1913–14, p. 95, 1914.

[2] Min. and Sci. Press, Jan. 13, 1917, p. 65.

[3] For discussion of geology see Cross, Whitman, and others, U. S. Geol. Survey Geol. Atlas, La Plata folio (No. 60), 1899. Emmons, W. H., The Neglected mine and near-by properties, Durango quadrangle, Colo.: U. S. Geol. Survey Bull. 260, pp. 121–127, 1905.

## MESA COUNTY.

A small lot of copper ore was shipped from the Super-Six mine in the Unaweep district.[1]

## MINERAL COUNTY.

*Mine production in Mineral County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine oz.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 9 | 28,071 | $33,039 | 291,807 | 8,943 | 2,382,128 | 85,984 | $305,172 |
| 1916 | 9 | 38,103 | 31,124 | 373,956 | 13,138 | 2,295,087 | 240,575 | 471,017 |
| Increase or decrease, 1916 | | +10,032 | −1,915 | +82,149 | +4,195 | −87,041 | +154,591 | +165,845 |

*Creede district.*[2]—The Creede district embraces the most important mineral deposits of Mineral County, and in 1916 the yield of the county was entirely from this district.

The Humphrey concentration-flotation mill was operated continuously on ore from the Park-Regent group and also from the Last Chance-Volunteer group. The output of the Humphrey mill was lead concentrates and some zinc concentrates. A 20-ton experimental chlorination mill (the process consisting of a blast roast with salt, bleaching with an acid brine solution, and precipitation on scrap iron) was operated for a period on silver ores from the Bachelor mine. None of the other mills in the district were operated, the remainder of the production being from lead and dry silver ore shipped to smelters. The smelting ore shipped increased from 10,864 tons in 1915 to 19,677 tons in 1916.

The producing mines at Creede were the Alpha, Bachelor, Commodore, Corsair, Holy Moses, Solomon, New York-Last Chance-Volunteer, Park-Regent, Kreutzer Sonata, and Quintette.

## MOFFAT COUNTY.[3]

Placer mines in the Fourmile district and copper mines in the Douglas Mountain district produced gold, silver, and copper having a total value of $3,212 for 1916.

*Craig district.*—No placer gold was recovered in this district in 1916.

*Douglas Mountain district.*—From the Bromide and Escalante mines small lots of silver-copper ore were shipped during the year.

[1] For discussion of geology see Butler, B. S., Notes on the Unaweep copper district, Colo.: U. S. Geol. Survey Bull. 580, pp. 19–23, 1914; Emmons, S. F., Copper in the "Red Beds" of the Colorado Plateau region: U. S. Geol. Survey Bull. 260, p. 227, 1905.

[2] For discussion of the geology of the district see Emmons, W. H., and Larsen, E. S., A preliminary report on the geology and ore deposits of Creede, Colo.: U. S. Geol. Survey Bull. 530, pp. 42–65, 1913.

[3] White, C. A., On the geology and physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming: U. S. Geol. Survey Ninth Ann. Rept., p. 691, 1889; Gale, H. S., Gold placers near Lay, Routt County, Colo.: U. S. Geol. Survey Bull. 340, pp. 84–85, 1908; Carnotite and associated minerals in western Routt County, Colo.: idem, pp. 257–262.

*Fourmile district.*[1] (*near Baggs, Wyo.*).—The producing placer mines in this district were the Arrowhead, Hawkeye, and Timberlake.

*Lay district.*—Only assessment work was done on the placer prospects of this district.

## MONTEZUMA COUNTY.[2]

Several cars of gold-silver ore were shipped from the Gold Dollar mine in the California district, but on the west slope of the west ridge of the La Plata Mountains, in Montezuma County.

A car of silver-copper ore from the Missouri Girl mine and a small lot of similar ore from the Bell Hamilton mine were shipped from the Bear Creek district on Dolores River, 14 miles south of Rico.

## MONTROSE COUNTY.[3]

A small lot of silver-copper ore was shipped from the Placerville mine, in the La Sal district. A small lot of copper ore was shipped from an abandoned prospect called the Monte Carlo, in the Sinbad Valley. No placer gold was recovered during the year from the various small deposits along Dolores River in this county.

## OURAY COUNTY.[4]

*Mine production in Ouray County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 38 | 103,258 | $1,118,016 | 576,621 | 863,851 | 1,990,681 | 7,282 | $1,656,002 |
| 1916 | 52 | 111,192 | 491,175 | 803,461 | 444,081 | 2,339,029 | 69,015 | 1,299,737 |
| Increase or decrease, 1916 | −14 | +7,934 | −626,841 | +226,840 | −419,770 | +348,348 | +61,733 | −356,265 |

*Red Mountain district.*—The Red Mountain district in 1916 produced 6,318 tons of ore, yielding $11,082 in gold, 19,777 ounces of silver, 189,752 pounds of copper, 245,551 pounds of lead, and 27,925 pounds of zinc, having a total value of $91,459, as compared with $53,200 in 1915.

For some years past this district has not been very active, the only work being that done by lessees on the mine and mill of the Barstow property. During 1916 there were 15 producing properties in this district, including the Atlantic, Barstow, Carbonate King, Curtis, Hudson, Iron City, Jumbo, Keno, Maud S., National Belle, Rogers,

[1] Hoover, H. C., Geology of Fourmile Placer, Colo.: Eng. and Min. Jour., vol. 63, p. 510, 1897.

[2] See La Plata County.

[3] Boutwell, J. M., Vanadium and uranium in Utah: U. S. Geol. Survey Bull. 260, pp. 202–203, 1905. Hillebrand, W. F., and Ransome, F. L., On carnotite and associated vanadiferous minerals in western Colorado: U. S. Geol. Survey Bull. 262, pp. 14–16, 1905. Emmons, W. H., The Cashin mine, Montrose County, Colo.: U. S. Geol. Survey Bull. 285, pp. 125–128, 1906.

[4] For discussion of geology see Cross, Whitman, and Howe, Ernest, U. S. Geol. Survey Geol. Atlas, Ouray folio (No. 153), 1907; Silverton folio (No. 120), 1905; Irving, J. D., Ore deposits of the Ouray district, Colo.: U. S. Geol. Survey Bull. 260, pp. 50–77, 1905. Ransome, F. L., A report on the economic geology of the Silverton quadrangle, Colo.: U. S. Geol. Survey Bull. 182, pp. 1–165, 1901.

Vanderbilt-Genessee, and Vernon. Much of this ore was sent direct to the Durango smelter, some to the Silver Lake custom mill at Silverton, and some to the flotation plant (new in 1916) at the Durango smelter, built by the smelting company for the purpose of removing the undesirable zinc, which had become so heavy in the ores and concentrates of the San Juan region as to interfere seriously with smelting.

*Sheffels district.*—Despite the closing down of the Camp Bird mine and mills in August, 1916, this district continued to be the principal producer in Ouray County. In 1916 from five mines there were sold or treated 98,814 tons of ore, from which were recovered $462,134 in gold, 681,936 ounces of silver, 97,520 pounds of copper, and 1,585,855 pounds of lead, with a total value of $1,044,262, as compared with $1,259,367 in 1916. This district in 1911 produced $2,162,198, the production having fallen after that year to a yearly output of little more than $1,000,000.

The Atlas 20-stamp, 8-foot Hardinge pebble mill flotation plant[1] was operated steadily. The Smuggler Union Mining Co., with properties in San Miguel County, extended its underground workings into Ouray County into the Humboldt group, and throughout the entire year moved the ore extracted from the Humboldt group back to the Smuggler Union mill in the Upper San Miguel district, keeping a separate record of the output of bullion and concentrates derived from this Ouray County property. Ouray County is thus given a very appreciable output for the year 1916, that might otherwise have been credited to San Miguel County had not the Smuggler Union Co. been able to furnish exact data. During the year very rich gold was found in some pockets along the Governor vein, and this high-grade gold was treated by amalgamation and the resulting bullion was shipped to the mint. A small lot of silver-lead ore was shipped from the Mountain Top mine. During the year there was in course of construction at this plant an underground wet concentration mill with tables and flotation cells. The Camp Bird mine and a section of its 60-stamp concentration-cyanidation mill was operated until June 24, 1916, although it took some little time after that to make a thorough clean-up in both mills. The equipment at the mine was dismantled and stored on the surface and offered for sale, and the mill will not be operated pending the completion of the new low-level adit, which will be 450 feet below present deepest workings and 800 feet below workings of the next most important section. The public annual report[2] of the Camp Bird (Ltd.) for the year ended June 30, 1916, says of the Camp Bird mine:

> The old base of mine operations is at the mouth of No. 3 tunnel, at an elevation above sea level of 11,300 feet. A new base has now been established at the mills having an elevation of 9,790 feet, from which a crosscut tunnel is being driven to intersect the Camp Bird vein some 10,700 feet away.
>
> Production and development were confined to the territory tributary to shaft No. 3 and crosscut north from second level west into Camp Bird territory heretofore unexplored at any considerable depth, all of which is tributary to the old base of operations, and all mention of mine work in this report bears reference to this base, except remarks under the caption The Camp Bird Tunnel, Mining, & Transportation Co.

[1] For description of mill see Carroll, F., Colorado Bur. Mines, Thirteenth Bienn. Rept. for 1913–14, p. 71, 1914; Min. and Sci. Press, June 24, 1916, pp. 953–954.

[2] See also Eng. and Min. Jour., May 26, 1917, p. 940; Min. Mag. (London), January, 1917, pp. 20–30.

Profit from operations during this period has been nearly double the estimated ore reserves of one year ago, accounted for in ore disclosures, not then apparent, in the hanging wall, ninth level, and a small body in seventh level No. 2 west of shaft No. 3. It is now to be observed that ore reserves are nil, that production has ceased owing to the exhaustion of ore to the floor of ninth level, that the old base of mine operations has been abandoned, and that operation at this time is confined to driving a crosscut from the new base.

The last ore was hoisted from the mine on June 12, 1916, and the stamp mill ceased operating on June 24, 1916. It will require several weeks' time to pass the present charge through the cyanide mill and make a thorough clean-up in both mills. * * *

The earnings for the year are as follows:

| | |
|---|---|
| Gross | $800,924 |
| Expenses (except taxes) | 292,041 |
| Net | 508,883 |
| Taxes charged | 14,897 |
| Balance after taxes | 493,986 |
| Miscellaneous revenue | 4,452 |
| Profit at mines and mills (exclusive of depreciation) | 498,438 |

Exclusive of depreciation of equipment the cost is $9.63 per ton. There was in addition $2.66 per ton expended in development work as against $1.60 the previous year. It will be observed that there was $17,171 more expended this year in development and the tonnage treated is 25.6 per cent less than last year. Obviously there is an increase in the rate per ton to the extent of $1.06. * * *

During the year there were 7,425 tons of ore broken down in the stopes and in development, all of which was delivered to the mills. There were July 1, 1915, in stopes, 15,188 tons, in chutes 300 tons, in mill bins 300 tons, to which must be added an excess of weights over measurements of 3,024 tons, making a total of 26,237 tons (net weight), or 25,601 tons (dry weight) treated, yielding $791,749.55, an average per ton of $30.92 as compared with $29.47 last year. * * *

Of the gold in crude ore there was a saving of 97.13 per cent, and a saving of 95.19 per cent in the combined value of gold and silver. * * *

The Camp Bird Tunnel, Mining & Transportation Co. * * * is organized under the laws of Colorado for the purpose of driving a crosscut to the Camp Bird vein, to locate any veins intersected not previously located, and to collect for transportation from all other companies or individuals which may be served.

The preparatory work was commenced in December, consisting of grading the approach, erecting buildings, and installing plant. By March 31, 1916, this work had largely been accomplished and the tunnel advanced 329 feet. Regular and systematic driving was commenced about April 1, and during the months of April, May, and June 972 feet were driven. The ground is exceedingly hard, with, in the State of Colorado, a labor shortage now showing some improvement due largely to an advance in wages. * * *

*Uncompahgre district.*—The Uncompahgre district produced in 1916 from 31 mines, 6,060 tons, yielding $17,959 in gold, 101,748 ounces of silver, 156,809 pounds of copper, 507,623 pounds of lead, and 41,090 pounds of zinc, with a total value of $164,016, as compared with $343,435 in 1915.

The Wanakah copper matting plant was idle the entire year, although there was some flue dust and other material shipped during the year. The Wanakah Co.'s 20-stamp amalgamation-concentration mill was also idle. Considerable development work was done at the American-Nettie mine, and a small quantity of ore was treated in the 3½-foot Huntington mill having amalgamation and a Wilfley table. Lead ore was also shipped from the Bachelor; silver-gold ore from the Black Girl; silver-lead from the Calliope, El Mahdi, and Lead-

ville. From May to November the Mineral Farm mine and from August to November the 20-stamp mill with concentrating tables and "Cascade" flotation cells were operated. Other producing mines were the Pony Express, Float, Great Western, Newsboy, Raven, Rose, Senorita, Trout, Wedge, Wewissa, and Yellow Jacket. The ore shipped from the Yellow Jacket mine was lead-zinc. A mill is proposed at this property. Ouray County has never been an important producer of zinc although its ores contain a considerable quantity of this metal. The ore from the Yellow Jacket mine was shipped to an eastern smelter for making leaded-zinc oxide.

## PARK COUNTY.[1]

*Mine production in Park County, Colo., in 1915 and 1916.*

| | Number of producing mines. | Ore. | Gold. | | Silver.[a] | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Placer. | Deep. | | | | | |
| | | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 17 | 2,820 | $9,792 | $149,547 | 9,227 | 12,303 | 190,830 | 472,992 | $233,790 |
| 1916 | 15 | 3,005 | 10,421 | 223,878 | 13,231 | 22,598 | 330,609 | 47,560 | 277,749 |
| Increase or decrease, 1916 | −2 | +185 | +629 | +74,331 | +4,004 | +10,295 | +139,779 | −425,432 | +43,959 |

[a] Includes placer production.

There were 12 producing deep mines and 3 placers in this county in 1916, a decrease of 2 deep mines but the same number of placers as in 1915. The placer yield was $10,421 in gold and 67 ounces of silver, as compared with $9,792 in gold and 73 ounces of silver in 1915.

*Beaver district.*—The placer mines in this district were idle.

*Buckskin district.*—A small quantity of gold ore from the Paris mine was treated in the amalgamation mill on the property. A car of lead ore and a car of zinc ore was shipped from the Rollins Phillips mine.

*Consolidated Montgomery district.*—A car of silver-lead ore was shipped from the Weber group. Lessees on the Magnolia mine shipped one car of gold-silver ore. Later in the year the Magnolia, Lee Goss, and other claims were taken over by a new company, and the Magnolia mill was reconstructed into a 25-ton cyanidation mill, with promise of operation during 1917.

*Freshwater district (Guffey).*—Development work was done at the Mill Gulch mine in this district.

*Horseshoe district.*—Several cars of zinc-carbonate ore were shipped from the Chance-Hilltop mine. The Snowstorm placers were operated for a period.

*Lake George (Pulver) district.*—The Great Western property, opened by a 210-foot vertical shaft and 750 feet of drifts, was unwatered during 1916, and on the 200-foot level was encountered mineral carrying zinc, lead, copper, and silver, the predominate metal being zinc.

[1] For discussion of geology see Patton, H. B., Hoskin, A. J., and Butler, G. M., Geology and ore deposits of the Alma district, Park County, Colo.: Colorado Geol. Survey Bull. 3, 1912.

*Mosquito district.*—The London mine,[1] at the head of Mosquito Creek, on the ridge between Leadville and Alma, continued to be a very important producer of gold ore. A small shipment of ore was also made from the Weston mine.

*Tarryall district.*—During the summer months the Fortune placers, 4 miles from Como, on Tarryall Creek, were operated by hydraulicking, with a considerable output of gold bullion averaging 0.890 fineness gold and 0.106 fineness silver. A small lot of copper ore was shipped from the Apex mine at the head of Tarryall Creek.

*Webster district.*—A car of silver-lead-copper ore was shipped from Webster during the year.

## PITKIN COUNTY.[2]

*Mine production in Pitkin County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 13 | 108,579 | $29 | 448,915 | 19,983 | 19,265,213 | 214,952 | $1,163,245 |
| 1916 | 12 | 114,330 | ..... | 577,863 | 28,931 | 17,519,275 | 162,574 | 1,617,966 |
| Increase or decrease, 1916.... | −1 | +5,751 | −29 | +128,948 | +8,948 | −1,745,938 | −52,378 | +454,721 |

*Aspen (Roaring Fork) district.*—At Aspen are located all the principal producing mines in Pitkin County, nearly all of which were operated by the Smuggler Leasing Co. The quantity of milling ore sent to the Smuggler 360-ton concentrating mill,[3] was somewhat less than in 1915, but the quantity of lead and dry ores shipped direct to smelters increased appreciably. Producing mines in the district were the Aspen Fraction, Della S., Spar, Bushwacker, Durant, Pride of Aspen, and Smuggler. Zinc-lead sulphide ores were shipped from the Durant mine.

The Hope Co., a local corporation, continued to drive its crosscut adit to cut the Little Annie and other mines at depth. At the end of the year this adit was within several hundred feet from the Little Annie shaft.

*Ashcroft (Columbia) district.*—No work was done in this district in 1916.

## RIO GRANDE COUNTY.

*Summitville district.*—No output was made in this district in 1916, but some development work was done at various properties. (See also Conejos County.)

[1] For discussion of geology see Moore, C. J., The London mine, Mosquito district, Colo.: Am. Inst. Min. Eng. Bull. 75, pp. 415–427, March, 1913.

[2] For discussion of geology see Spurr, J. E., Geology of the Aspen mining district, Colo., with Atlas: U. S. Geol. Survey Mon. 31, 260 pp., 1898.

[3] For description of mill see Anderson, C. E., Colorado Bur. Mines Thirteenth Bienn. Rept. for 1913–14, pp. 104–105, 1914.

## ROUTT COUNTY.[1]

*Hahns Peak district.*—Sluicing operations near Hahns Peak resulted in a small output of gold bullion. A small shipment of silver ore was made from Columbine. Development work was continuous at the Royal Flush group and the concentration mill was reconstructed to use a ball mill, classifier, and flotation cells.

*Slater district.*—Assessment work only was done in this district.

*Yarmony district.*—The leaching plant constructed during 1915 at the Copper King claim was operated for a period, with a yield of one car of copper precipitates from the treatment of copper carbonate in sandstone.

## SAGUACHE COUNTY.

*Mine production in Saguache County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 10 | 692 | $5,273 | 11,266 | 23,360 | 174,447 | 44,250 | $28,759 |
| 1916 | 20 | 3,338 | 8,024 | 48,959 | 92,581 | 255,449 | ..... | 80,640 |
| Increase or decrease, 1916 | +10 | +2,646 | +2,751 | +37,693 | +69,221 | +81,002 | −44,250 | +51,881 |

*Baca Grant (Crestone) district.*—Only assessment and development work was done in this district during 1916.

*Baca Grant (Music or Liberty) district.*—Some development work was done in this district.

*Cochetopa district.*—The Alaska-Yukon property was idle.

*Crystal Hill district.*—A shipment of gold-silver ore was made from the Esparanza mine.

*Iris district.*—No work was done at the Denver City mine, at Iris, 16 miles southeast of Gunnison, from which a car of lead-zinc sulphide ore was shipped in 1916.

*Kerber Creek (Bonanza) district.*—This district is the principal producing district in the county. There was a considerable increase in the yield for 1916. The producing mines were the Antoro, Cocomogo, Cornucopia, Empress Josephine, Michigan-Paragon, Minnie Lynch, Paddy Doyle, Rawley, and St. Louis.

[1] For discussion of geology see George, R. D., and Crawford, R. D., The Hahns Peak region, Routt County, Colo.: Colorado Geol. Survey First Rept. for 1908, pp. 189–220, 1909. Gale, H. S., The Hahns Peak gold field: U. S. Geol. Survey Bull. 285, pp. 28–34, 1906; White, C. A., On the geology and physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming: U. S. Geol. Survey Ninth Ann. Rept., p. 691, 1889.

## SAN JUAN COUNTY.[1]

*Mine production in San Juan County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 42 | 147,878 | $583,681 | 430,637 | 1,054,463 | 6,791,596 | 2,259,226 | $1,585,894 |
| 1916 | 46 | 146,128 | 438,628 | 502,342 | 1,615,167 | 7,285,304 | 4,014,403 | 2,207,116 |
| Increase or decrease, 1916 | +4 | −1,750 | −145,053 | +71,705 | +560,704 | +493,708 | +1,755,177 | + 621,222 |

*Animas district (including the mines in the vicinity of Silverton and south and east of Animas River from Silverton to Middleton).*—The Animas district in 1916 produced 66,713 tons of ore, yielding $203,683 in gold, 319,310 ounces of silver, 934,077 pounds of copper, 3,194,898 pounds of lead, and 133,313 pounds of zinc, with a total value of $881,884, as compared with $568,640 in 1915.

There were 27 producing mines in the district, chief of which were the Iowa-Gold Tiger group and the Silver Lake mines. The Silver Lake mines were operated throughout the year by lessees, and the Silver Lake mill was operated continuously as a custom plant on ores from Red Mountain district, Eureka district, and Animas district. The equipment of the Silver Lake mines consists of rolls, jigs, Chilean mill, Wilfley tables, and flotation cells. A large quantity of old tailing from the Silver Lake mines was flumed to the Mears-Wilfley mill, which is a 500-ton ball mill followed by flotation equipment. The Iowa-Gold Tiger mine and 100-ton concentration mill, equipped also with flotation cells, was operated steadily. Work was resumed at the Hercules mine during the year and a large quantity of ore was shipped to the Silver Lake mill for treatment. The 40-stamp concentration mill on the property was also operated for a period. The Intersection 10-stamp amalgamation and concentration mill was operated during the year. The Kittimac mine and reconstructed mill were operated during part of the year. Lead ore was shipped from the Dives and Dives Fraction. Other producing mines were the Aspen, Barbara, Champion, Frank Waller, North Star (King Solomon Mountain), Emerald, Fairview, Highland Mary, Hamlet, Kansas City, Mayflower, North Star (Sultan Mountain), Pride of the West, Sultana, and Yellow Jacket.

*Eureka district (north of Silverton, including Chattanooga, Gladstone, Animas Forks, Eureka, and Red Mountain).*—This district in 1916 produced 79,385 tons of ore, yielding $234,888 in gold, 182,912 ounces of silver, 681,069 pounds of copper, 4,086,290 pounds of lead, and 3,881,090 pounds of zinc, with a total value of $1,324,811, as compared with $1,017,254 in 1915. The Sunnyside mine and amalgamation and concentration mills (one 40-stamp and one 10-stamp, including one 25-ton Huff electrostatic separating plant and also

[1] For discussion of geology, see Cross, Whitman, Howe, Ernest, and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Silverton folio (No. 120), 1905. Emmons, W. H., Ore deposits of Bear Creek, near Silverton, Colo.: U. S. Geol. Survey Bull. 285, pp. 25–27, 1906. Ransome, F. L., A report on the economic geology of the Silverton quadrangle, Colo.: U. S. Geol. Survey Bull. 182, pp. 1–265, 1901.

flotation machines) were operated steadily, with a product of gold-silver bullion, lead concentrate, and zinc concentrate. The Gold King Leasing Co. operated the Gold King mine and a 150-ton concentration and flotation mill throughout the year. A considerable quantity of copper ore was shipped from the Congress mine direct to smelters, and also to the Silver Lake custom mills. Copper-lead ore from the St. Paul mine, and silver-copper ore from the Carbon Lake mine was shipped to smelters.

*Ice Lake Basin district.*—In this district west of Silverton a small quantity of ore from the Two Marys claim was treated in the small amalgamation mill on the property, and a small lot of silver-lead ore was shipped from the Emma mine.

## SAN MIGUEL COUNTY.[1]

*Mine production in San Miguel County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 25 | 483,954 | $2,069,362 | 1,036,641 | 562,554 | 5,240,277 | 1,040,121 | $3,099,074 |
| 1916 | 20 | 428,651 | 2,072,393 | 812,041 | 581,427 | 6,126,551 | 1,098,485 | 3,319,676 |
| Increase or decrease, 1916 | −5 | −55,303 | +3,031 | −284,600 | +18,873 | +886,274 | +58,364 | +220,602 |

*Upper San Miguel district.*—The Upper San Miguel district in 1916 produced 424,794 tons of ore, yielding $2,057,586 in gold, 804,795 ounces of silver, 568,947 pounds of copper, 6,088,319 pounds of lead, and 1,098,485 pounds of zinc, with a total value of $3,294,393, as compared with $3,065,758 in 1915.

The three large companies, the Liberty Bell, the Smuggler Union, and the Tomboy, continued to furnish the greater part of the total output, which also includes a large quantity of ore treated at the Smuggler Union mill from the Black Bear mine. The Smuggler Union mill also treated a large quantity of ore from the Humboldt mines (in Ouray County), proper credit for which is given to Ouray County. The amalgamation-concentration mill of the Wagner Development Co. was also operated at half capacity throughout the year.

The annual report of the Liberty Bell Gold Mining Co. for the year ending September 30, 1916 (dated January 16, 1917) says:

> The conspicuous facts of the year's operations are: (1) A reduction in the tonnage of ore handled; (2) an increase of operating costs both gross and per ton; (3) an increase in income both gross and net.
>
> The reduction of ore handled from 174,100 tons to 165,300 tons was due to the scarcity of labor during a great part of the year and to the scattered and irregular nature of the mining. The scarcity of labor was caused principally by the activity and high wages paid in other fields, especially in the copper camps.

[1] For discussion of geology, see Purington, C. W., Preliminary report on the mining industries of the Telluride quadrangle, Colo.: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 745-850, 1898. Cross, Whitman, and Purington, C. W., U. S. Geol. Survey Geol. Atlas, Telluride folio (No. 57), 1899. Hess, F. L., Notes on the vanadium deposits near Placerville, Colo.: U. S. Geol. Survey Bull. 530, pp. 142-156, 1912.

Operating costs increased from $643,009 to $670,912, and this for 5 per cent less tonnage mined, so that the cost per ton was raised by 35 cents. This increase was also due to the scattered and irregular mining, to the higher costs of materials, and to higher wages in the form of a bonus based on silver prices. * * *

The most important development of the year was the final elimination of the western ground and its areas of probable ore, and the driving of X level about 150 feet below the tunnel. This demonstrated the continuance of an ore shoot of a good grade of ore, which is, however, only about 400 feet wide and will not yield a large tonnage. Further sinking and driving are planned, which will probably develop another small block of ore, but very much is not to be expected from this work. It is a curious coincidence that the center and greatest depth of the ore shoot has been found in the middle of the property and at the place of largest early developments through tunnel and upraise. This condition misled us in our expectations, as the levels driven both east and west from this central area showed absence of ore at depth.

Since the end of the fiscal year a lease has been entered into with the Smuggler Union Co. for the mining of ore in ground of that company adjoining our property to the east. It is probable that sufficient ore will be obtained from this ground to sustain operation for a year or so longer, but developments have not proceeded far enough to make this a certainty.

As shown in the section at the end of the report, the ore in sight and probable (140,000 tons), exclusive of that in the leased Smuggler Union ground, is not very much reduced below what was estimated at the end of the preceding year. * * *

*Summary of operating receipts and expenses.*

| | Total. | Rate per ton. | | |
|---|---|---|---|---|
| | | 1916 | 1915 | 1899–1916 |
| Receipts: | | | | |
| Ore proceeds (165,300 tons) | $791,788.33 | $4.79 | $3.80 | $6.30 |
| Stamp bullion | $541.41 | ..... | .01 | 2.95 |
| Cyanide products | 730,272.36 | 4.42 | 3.45 | 2.63 |
| Concentrates | 60,974.56 | .37 | .34 | .66 |
| Concentrate cyanide bullion | ..... | ..... | ..... | .05 |
| Slag | 3,936.24 | | | .01 |
| Boarding-house profit | 4,076.35 | | | ..... |
| Tram receipts | 3,136.50 | .19 | .16 | .18 |
| Rental receipts | 2,244.64 | | | ..... |
| Commissary profit | 18,277.06 | | | ..... |
| Interest and profits from investments | ..... | ..... | ..... | ..... |
| Total receipts | 823,459.12 | ..... | ..... | ..... |
| Average receipts per ton milled | ..... | 4.98 | 3.96 | 6.48 |
| Expenses: | | | | |
| General expenses (165,300 tons) | 54,727.00 | .33 | .32 | .62 |
| Mining (164,800 tons) | 314,475.94 | 1.91 | 1.64 | 2.22 |
| Operating | 266,171.70 | 1.62 | 1.43 | ..... |
| Development work (6,531 feet) | 48,304.24 | ..... | .21 | ..... |
| Tramming (164,900 tons) | 23,072.77 | .14 | .13 | .25 |
| Milling (165,300 tons) | 245,585.05 | 1.49 | 1.39 | 1.58 |
| Treatment and shipping costs | 33,051.32 | .20 | .22 | .26 |
| Stamp bullion (102 ounces) | 18.50 | .18 | a.15 | ..... |
| Concentrates (3,558 tons) | 28,576.09 | 8.03 | 10.54 | ..... |
| Cyanide bullion (278,064 ounces) | 4,456.73 | .02 | a.02 | ..... |
| Total operating expenses | 670,912.08 | ..... | ..... | ..... |
| Average cost per ton milled | ..... | 4.07 | 3.69 | 4.93 |
| Balance profit | 152,547.04 | ..... | ..... | ..... |
| Per ton milled, profit | ..... | .91 | .27 | 1.55 |

a Per ounce of bullion.

The annual report of the Tomboy Gold Mines Co. (Ltd.) for the year ending June 30, 1916, states:

*Argentine group.*—For reasons given in last year's report, no exploratory work was undertaken in the Argentine mine.

The lower levels of the mine contain large tonnages of ore (not included in our estimate) carrying from 2 per cent to 5 per cent each of lead and zinc and from 1 per cent to 2 per cent of copper, that will prove a valuable asset when a process can be applied that will effect both a high percentage of recovery and an economic separation of the constituent metals. Numerous tests by different processes have been made, and are still being carried on, with a view to bring about the successful treatment of these ores. Some of the tests, I am glad to say, have given very encouraging promises of success.

Since the date of last year's report all the stopes above the 600-foot levels have been drawn and milled. The pillars within the stopes, as well as the supports beneath the levels themselves, have also been mined.

We estimate the ore reserves of the Argentine mines, as of June 30, 1916, at 175,000 tons, of which 140,000 tons is ore broken in the stopes.

*Montana group.*—Development work in the Montana mine aggregated 5,159 feet and was made up of 4,676 feet of drifting, 467 feet of raises, and 16 feet of crosscuts. The old Revenue raise was straightened, retimbered, and converted into a shaft for an additional distance of 168 feet to a point 25 feet below the 2,050-foot level.

The advance work for the year, as shown on the stope map, was, of course, mainly northward, but also upward and downward. We also opened up a new stope at the south end of the mine, above the Ophir level, that gives promise of extending northward to the vicinity of 42 raise.

Raise No. 125 was extended to a connection with the old Montana surface adit, and that drift reopened and retimbered to the portal. This raise, in addition to developing the vein to the elevation of the Montana adit, has very materially improved the natural ventilation of the mine.

The conversion of the old Revenue raise into a shaft to the 2,050-foot level has developed the vein for 150 feet below the 1,900-foot level, and added a considerable block of ground to the ore reserves of the mine. * * *

It will be noticed that the 1,100 feet of progress on the Ophir level has carried this level beyond the northern limits of the Bushwhacker claim (partly in Ouray County), and beyond the northern boundary of the company's property at the date of last report. This extension of operations was made possible by the purchase, in the latter part of 1915, of nearly 4,000 feet of additional ground in the direction of the strike of the Montana vein. The new purchase also includes 1,500 feet along and covering the strike of a cross-vein known as the Sidney vein. It was the original intention to develop the newly purchased territory by extending into it both the Fortuna drift and the North drift on the Ophir level. Very difficult ground having been encountered on the Fortuna level, north of chute 183, it was decided to abandon exploratory work at this horizon, and confine the operations to the Ophir drift. It was also intended to develop the new purchase from the Ouray side of the Main Range through a crosscut tunnel known as the upper Sidney tunnel, at an elevation of about 650 feet north above the Ophir tunnel level; but on account of the great depth of snow on the north side of the mountain, it was impossible to undertake this development until June 30. Since that date the work of cleaning out and retimbering the old workings that have been in disuse for nearly 20 years has been prosecuted as rapidly as conditions would permit.

With the exception of two comparatively short shoots of milling ore disclosed by the Ophir tunnel north drift, no new ore bodies have been encountered as the result of the year's explorations. The known ore bodies, however, have been further explored, with the result that after milling in excess of 120,000 tons from the Montana mine, we have in reserve 50,000 tons more ore than we were able to estimate at the close of the previous year's operations.

We estimate the ore reserves of the Montana mine as of June 30 at 400.000 tons, of which 250,000 tons is ore broken in the stopes. * * *

The 60-stamp mill treated the largest tonnage of ore in its history, and was continuously operated throughout the year with very gratifying results.

The cyanide plant treated 132,200 tons of tailings, recovering therefrom bullion valued at $164,476.11, at a cost of $0.90 per ton, and yielding a net profit of $0.31½ per ton of tailings treated.

*Revenue and expenditure.*

| | | | |
|---|---|---|---|
| 150,488 dry tons ore milled, yielding bullion worth | | | $327,519.15 |
| Concentrates worth | | | 586,092.32 |
| Cyanide bullion worth | | | 160,476.11 |
| Dividends from the Tomboy Tramway & Tunnel Co | | | 10,000.00 |
| Boarding house, rents, etc | | | 19,566.22 |
| | | | 1,103,653.80 |
| | Per ton. | | |
| Mining and developing expenses | $2.42 | $363,466.74 | |
| Milling expenses | .52 | 78,593.32 | |
| Concentrating expenses (including transportation to railway) | .49 | 73,667.64 | |
| Water supply expenses | .09 | 13,783.40 | |
| Assay office expenses | .02 | 3,448.66 | |
| Cyaniding expenses | .79 | 118,773.17 | |
| General expenses | .20 | 30,005.52 | |
| Taxes and insurance | .26 | 39,127.33 | |
| Total expenses | 4.79 | | 720,865.78 |
| Profit | | | 382,788.02 |

Other producing mines were the Ballard, Cimarron, Columbine, Lucky, Modena, and Nellie.

*Iron Springs (Ames and Ophir) district.*—The Iron Springs district in 1916 produced 3,857 tons of ore, yielding $14,807 in gold, 7,246 ounces of silver, 12,480 pounds of copper, and 38,232 pounds of lead, with a total value of $25,283, as compared with $33,316 in 1915. The principal producing mine in this district was the Butterfly-Terrible, operated by lessees during part of the year. The product was chiefly in the form of gold-silver bullion from the mill on the property, with also a small quantity of concentrates and one car of ore direct to the smelter. Other producing mines were the Butler-Silver Bell, Charter Oak, Lookout, Oregon, Pike County, Suffolk, San Bernardo, and Santa Cruz.

*Lower San Miguel (Sawpit and Placerville) district.*—There was no yield of ore from this district for the metals under discussion in this report, but some iron pyrite ore containing a small quantity of gold (not recovered) was shipped for its iron and sulphur content, from the Lizzie G. mine for use in the treatment of vanadium ores.

*Mount Wilson district.*—Some assessment work was done in this district.

## SUMMIT COUNTY.

*Mine production in Summit County, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | | Silver.[a] | Copper. | Lead. | Zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Placers. | Deep. | | | | | |
| | | *Short tons.* | | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 41 | 44,602 | $607,195 | $72,949 | 64,223 | 8,646 | 1,916,298 | 8,597,411 | $1,870,363 |
| 1916 | 55 | 65,117 | 579,050 | 94,841 | 120,207 | 14,581 | 1,688,637 | 13,940,948 | 2,741,177 |
| Increase or decrease, 1916 | +14 | +20,515 | −28,145 | +21,892 | +55,984 | +5,935 | −227,661 | +5,343,537 | +870,814 |

[a] Includes placer production.

The value of the production of Summit County in 1916 was the largest in its history. Dredges[1] and other placer operations yielded $579,050 in gold and 7,292 ounces of silver, valued at $4,798, a total of $583,848, against $607,195 in gold and 7,487 ounces of silver in 1915.

The principal placer-producing district in Colorado is near Breckenridge, Summit County. This county is also one of the three principal zinc-producing counties, being exceeded only by Lake and Eagle counties.

*Breckenridge district.*[2]—The Breckenridge district includes the the Bevan, Minnesota, and Union districts and contains the mines (near Breckenridge) on French Gulch and on Blue and Swan rivers and all the placers in the county. The value of the total output of gold, silver, copper, lead, and zinc from both deep and placer mines was $2,556,807, or 93 per cent of the county yield, and an increase in 1916 of $760,170, following an increase in 1915 over 1914 of $814,308.

The Wellington mine continued to be the principal producing property in the district. The 125-ton wet-concentration mill, with rolls, jigs, and tables, and the 100-ton magnetic separation plant,[3] with rolls, roasters, and magnetic separation tables, were operated continuously with a heavily increased output of lead and zinc concentrates. In addition, a considerable quantity of high-grade zinc ore was shipped direct to smelters. Lessees on the Dunkin mine again shipped considerable metallic gold found in pockets and in addition shipped several cars of high-grade gold ore direct to the smelter. Lessees on the Country Boy mine shipped low-grade zinc ore to the Pingrey mill, at Leadville, and several cars of high-grade zinc ore direct to smelters. A small mill was operated for a period on ore from the dump of the Puzzle mine, and later in the year lessees reopened the Puzzle-Gold Dust property and shipped a considerable quantity of ore. Other producing mines were the Brooks-Snyder, Farncomb Hill, Germania, Hamilton, Jessie, Lucky, Mountain Gem, New York, Pacific, and Washington.

All four of the dredges in the district were operated in 1916, but with a decreased output as compared with 1915. The three dredges of the Tonopah Placers Co. were put in operation during the month of March, 1916, and continued in operation until the end of December, at which time the two large dredges were closed down (on account of the winter weather) and the smaller dredge continued in operation until the latter part of January, 1917. One of the dredges was operated during the whole season upon property owned by the Farncomb Hill Gold Dredging Co., under contract with that company. The net earnings of the dredge while on this property will be divided equally between the Farncomb Hill Gold Dredging Co. and the Tonopah Placers Co. Two of these dredges are of the Bucyrus open-connected type, with buckets of a capacity of 9½ cubic feet; the other dredge is of the double-lift, open-connected type, with buckets of a capacity of 9 cubic feet.

[1] See Revett, B. S., Gold dredging: Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 128–131, 1914.

[2] For discussion of the geology of the district see Ransome, F. L., Geology and ore deposits of the Breckenridge district, Colo.: U. S. Geol. Survey Prof. Paper 75, 1911.

[3] For description of magnetic plant see Parmalee, H. C., Zinc ore dressing in Colorado: Met. and Chem. Eng., September, 1912, pp. 525–528. Also for description of mills see Henderson, R. M., Colorado Bur. Mines Thirteenth Bienn. Rept. for 1913–14, pp. 106–110, 1914.

The report of the Tonopah Placers Co. for the 10 months ending December 31, 1916, appears in the fifteenth annual report of the Tonopah Mining Co. of Nevada:

*Production of Tonopah Placers Co. for 10 months ending December 31, 1916.*

| | |
|---|---|
| Gross value of bullion shipped to mint | $406,367.68 |
| Cost of operations | 257,138.76 |
| | 149,228.92 |
| Cubic yards dredged | 3,199,962 |
| Gold produced, ounces | 19,558.68 |
| Silver produced, do | 4,748.16 |
| Value per yard | $0.127 |
| Profit per yard | $0.055 |

Bullion from the Tonopah Co.'s dredges averaged in fineness 0.798 gold and 0.194 silver. The French Gulch Dredging Co., or Reiling dredge (Bucyrus type), with buckets of a capacity of 5 cubic feet, operated for nine months. Bullion from the French Gulch dredge averaged in fineness 0.747 gold and 0.230 silver. The Bemrose, Key West, and Mekka placers were operated by hydraulicking and sluicing.

*Consolidated Tenmile district (Frisco, Kokomo, and Robinson).*[1]—This district in 1916, from 16 mines, produced 11,553 tons of ore yielding $17,575 in gold, 40,935 ounces of silver, 5,809 pounds of copper, 376,913 pounds of lead, and 66,672 pounds of zinc, with a total value of $80,880, as compared with $25,388 in 1915.

The Robinson mine and magnetic separator and wet-concentration mill[2] was taken over by the Progress Mining & Milling Co., remodeled to include the flotation process, and operated during the latter part of the year as a custom plant, treating ores from various properties at Kokomo and vicinity. A large quantity of both lead and iron silver-gold ores were shipped from the Michigan mine during the year, and a considerable quantity of silver ore was shipped from the Golden Queen mine. A considerable quantity of lead-zinc and lead-silver ore was shipped from the Wilfley-Kimberly property. Other producing mines from which small shipments were made were the Avalanche (Four Most), Columbine, Excelsior, and King Solomon, at Frisco, and Boston, Colonel Sellers, Free America, Mayflower, Pearl, Result, and Resurrection, at Kokomo.

*Montezuma district.*[3]—This district in 1916, from 8 mines, produced 9,544 tons of ore yielding $1,205 in gold, 21,369 ounces of silver, 6,195 pounds of copper, 441,652 pounds of lead, and 419,597 pounds of zinc, with a total value of $103,490, as compared with $48,338 in 1915.

The Montezuma Mines & Milling Co., operating the Silver Wave, Silver Princess, and Chautauqua mines, operated its 50-ton concentration and flotation mill (completed Aug. 1, 1915) for a short period in 1916 and produced lead and zinc concentrates. Several claims of the Philadelphia Co. were worked, and a considerable quantity of lead-

[1] For discussion of geology see Emmons, S. F.: U. S. Geol. Survey Geol. Atlas, Tenmile district folio (No. 48), 1898.
[2] For description of mill see Parmalee, H. C., Zinc ore dressing in Colorado: Met. and Chem. Eng., February, 1911, pp. 91–96.
[3] For discussion of geology see Patton, H. R., The Montezuma mining district of Summit County, Colo.: Colorado Geol. Survey First Rept., 1908, pp. 104–144, 1909.

zinc ore was milled at the company's concentration mill, with output of lead and zinc concentrates. A car of silver-lead ore was shipped from the Clarion mine and several cars of silver ore were shipped from the Rainbow mine. During the latter part of the year, a tube mill and flotation cells were installed at the mill of the St. Johns Mines Co., and the reconstructed plant was operated for a period with a small output of lead concentrates. Several small lots of silver-lead ore were shipped direct to smelters from this property.

## TELLER COUNTY.

### CRIPPLE CREEK DISTRICT.[1]

*Mine production of Cripple Creek district, Colo., in 1915 and 1916.*

| Year. | Number of producing mines. | Ore. | Gold. | Silver. | | Total value. |
|---|---|---|---|---|---|---|
| | | | | Quantity. | Value. | |
| | | *Short tons.* | | *Fine ounces.* | | |
| 1915 | 70 | 948,082 | $13,683,494 | 87,767 | $44,498 | $13,727,992 |
| 1916 | 64 | 945,820 | 12,119,550 | 79,804 | 52,511 | 12,172,061 |
| Increase or decrease, 1916 | −6 | −2,262 | −1,563,944 | −7,963 | +8,013 | −1,555,931 |

In 1916 there were recovered in the Cripple Creek district by mills and smelters from crude ore and dump ore, from slags, slimes, and "clean-ups" of mills, from stolen bullion and ore, 586,283.23 fine ounces of gold, valued at $12,119,550.

#### CRIPPLE CREEK DRAINAGE OR ROOSEVELT TUNNEL.

The total progress made in the Roosevelt tunnel during the year 1916 is reported as 2,311 feet. In addition, considerable work was done in the vicinity of the Elkton main shaft. Crosscuts were driven and a raise made from the tunnel level to the bottom of the Elkton shaft (about 160 feet). The total length of the tunnel from portal to breast at the end of the year 1916 was 22,100 feet.

#### MILLS AT COLORADO CITY.

Of the 945,820 tons of crude mine ore and dump ore from the Cripple Creek district 37,111 tons, representing only 4 per cent of the total quantity, was sent direct to smelters. These 37,111 tons contained 84,570.24 fine ounces of gold and 31,603 fine ounces of silver, an appreciable decrease as compared with 1915. This smelting ore (the higher-grade ore of the district) carried, however, 14 per cent of the total output of gold and 40 per cent of the total output of silver in the district. If to the gold and silver recovered at smelters is added the gold and silver contained in concentrates sent direct to smelters, but without including the concentrates sent to cyanidation mills at Colorado City, the smelters recovered from

[1] For discussion of geology see Lindgren, Waldemar, and Ransome, F. L., Geology and ore deposits of the Cripple Creek district, Colo.: U. S. Geol. Survey Prof. Paper 54, 1906.

Cripple Creek ores 16 per cent of the gold and 42 per cent of the silver produced in the district. The remainder of the gold and silver was in the form of the fine gold bars from cyanide precipitates, the yield from the treatment of 96 per cent of the total quantity of ore treated during the year.

The active valley mills adjoining Colorado City were the Golden Cycle, a roast-cyanide (with subsidiary amalgamation) plant[1] of 1,200 tons daily capacity, and the Portland, a 400-ton roast-cyanide concentration mill. The plants of the United States Reduction & Refining Co. at Colorado City and at Florence, Fremont County, were sold and will be dismantled.

### MILLS IN THE CRIPPLE CREEK DISTRICT.

On June 30, 1915, the Portland Gold Mining Co. purchased the Stratton's Independence mill, and during the rest of 1915 more attention was paid to the proposed changes and enlargements in this mill than to the treatment of ores. The Portland Co. has also operated continuously at Victor since June, 1910, its Victor concentration cyanide (nonroast) mill. The annual report of the Portland Co. for the calendar year 1916 says, regarding the Victor and Independence mills:

> The work of remodeling and enlarging our Independence mill has been somewhat delayed by the difficulty in securing machinery and building material, and to a lesser extent by reason of a change in our plans concerning the method of treatment to be used in this mill. The experiments conducted by us before the issuance of our last report showed that our nonoxidized ores could be treated with marked success by the oil flotation process, and we contemplated using this process in our remodeled Independence mill. Further investigation and study have demonstrated that this process does not bring satisfactory results when applied to oxidized ores. Oxidized ores predominate in the upper workings of our mines; and these are the ores that will be the most accessible to our Independence mill during the next five or six years. We have therefore decided to continue the use of the cyanide method of treatment in this mill, and have modified our plans accordingly. The reconstruction of the Independence mill is now well on the way toward completion. Its coarse crushing and sampling plant is virtually completed. * * *
>
> By the reconstruction of our Independence mill we are increasing its capac-ity from about 350 tons to about 1,400 tons daily. We hope to have it completed and in operation about June 1, 1917. The combined capacity of this plant and of our adjacent Victor mill will be in the neighborhood of 2,000 tons every 24 hours. The last-named mill has treated an average of 18,000 tons of low grade ore per month during the year 1916. When both of these plants are in operation, treating the low-grade ores of our mines and dumps, your company will, we believe, earn an amount measurably near to its dividend requirements from the treatment of its ores having a gross value of less than $3 per ton.

The Vindicator washing and concentrating mill, handling the rejects from the Vindicator ore house, was in continuous operation during the year 1916 and showed a very satisfactory profit, handling 127,947 tons of ore of an average value of $1.68 at an average cost of 17.4 cents a ton. The original ore handled by this washing mill has not been entered into the calculations of quantity of ore from Cripple Creek in this Geological Survey report because the Vindicator Co. ships this product from washing as ore. In April, 1916,

[1] For description see Milliken, J. T., Colorado Bur. Mines Thirteenth Bienn. Rept., 1913–14, pp. 72–74, 1914.

the Vindicator Co. authorized the construction of a 300-ton test mill to prove thoroughly the practicability of the Minerals Separation flotation process on Cripple Creek ores. The annual report for the year 1916 of the Vindicator Consolidated Gold Mining Co. says in regard to this flotation test mill:

> The construction work was started immediately, and on October 25 the plant was put in operation. * * * The metallurgical work may be said to have been started December 1. The ore delivered to the mill has been rejects from the Golden Cycle ore house, with an average value of approximately $2 per ton. * * * Results obtained from the test work in the comparatively short period of operations of the mill seem to warrant the statement that the Vindicator mine ore, as well as the dump ores, can be successfully and economically handled by the flotation process. During the past two weeks crude mine ore from the Vindicator shaft has been treated by the flotation mill without its being subjected to any ore-house treatment whatever, and the results obtained have been most gratifying. The ores which have been treated up to the 8th of January have been ore-house reject from the Cycle shaft, being the most convenient material obtainable, but ore that would give a low value of concentrate, and, of course, due to the low value of the heads, the percentage of extraction will necessarily be lower than from the treatment of ores of greater value. The results for operations from the first of December show as follows:

| | |
|---|---|
| Assay of head | $1.98½ |
| Assay of concentrate | $19.34 |
| Assay of tailing | $0.41 |
| Extraction, per cent | 81.2 |
| From January 1 to January 9: | |
| Assay of head | $2.26 |
| Assay of concentrate | $20.66 |
| Assay of tailing | $0.38 |
| Extraction, per cent | 84.4 |
| From January 9 to date, working on crude mine ores without sorting: | |
| Assay of head | $5.40 |
| Assay of concentrate | $40.25 |
| Assay of tailing | $0.375 |
| Extraction, per cent | 93.1 |

Other operating mills in the district were the Colburn-Ajax, a 300-ton concentration and cyanide mill[1] operated for a short period, after which the mill was closed down during experimentation with the flotation process; the new Dante (Reed) 60-ton cyanide leaching plant operated during part of the year; the Isabella 50-ton coarse-crushing cyanide leaching mill operated the greater part of the year; the Jerry Johnson (Caley) 100-ton cyanide mill operated intermittently during the year; the Rex 100-ton cyanide leaching plant operated for a short period; and the new Rubie (Worcester) 30-ton cyanide mill operated for a short time. The Free Coinage 60-ton cyanide and concentration plant, the Blue Flag 125-ton continuous agitation cyanide mill, and the Wild Horse 50-ton coarse-crushing cyanide leaching plant were idle.

### MINES REVIEW.

*Poverty Gulch.*—The Abe Lincoln, C. O. D., and Gold King mines were producers.

*Tenderfoot Hill.*—A considerable quantity of ore was shipped from the Queen Bess property, operated through the Mollie Kathleen

[1] For description see Bryan, R. R., Colorado Bur. Mines Thirteenth Bienn. Rept., 1913–14, pp. 75–76.

shaft. Several cars of ore were shipped from the Black Diamond mine. Operations at the Ella W. mine ceased.

*Globe Hill.*—Stratton Estate mines on this hill continued to produce.

*Hoosier Pass.*—There was no production from the Hoosier mine.

*North slope of Ironclad Hill.*—Producing mines were the Jerry Johnson, W. P. H., and Damon. The W. P. H. and Damon mines were operated by the United Mines Co., whose property comprises a large acreage on Bull Hill, as well as on Ironclad Hill.

*Gold Hill.*—Producing mines were the Anchoria-Leland and Midget.

*Raven and Guyot Hills.*—Producing mines were the Cresson, Doctor-Jack Pot, Elkton, Jennie Sample, Jo Dandy, and Mary McKinney. A large quantity of low-grade ore was shipped from the old Economic mill dump.

The Cresson property continued to be one of the principal producing mines in the district.

The twenty-fourth annual report of the Elkton Co. for the calendar year 1916, dated February 13, 1917, says:

It is with regret that we are compelled to report that the mining operations of your company for the year 1916 were very disappointing.

You will recall that the report submitted to you under date of February 14, 1916, stated that the main shaft had reached a depth of 125 feet below the sixteenth level, at which point a station was then being cut and equipped. This resulted shortly afterwards in opening the vein which was drifted on both north and south, which resulted in an astonishing decrease in gold values comparable with the values in levels above. The shaft was sunk as rapidly as possible to the Roosevelt Drainage Tunnel level, as stated in the annual report of 1916, and at this level the values were extremely disappointing.

These developments indicated that at last the Elkton had reached in depth the so-called lean zone, and it can only be hoped that with deeper developments (when possible to be had) there may show again an enrichment in the various veins. * * *

In the month of June, 1916, the Roosevelt Deep Drainage Tunnel reached the contiguous vicinity of the Elkton main shaft, thereby giving the Elkton Co.'s territory immediate and ample drainage, thus enabling the company to sink the main working shaft and connect it with the drainage tunnel at a point 1,636 feet below the collar of the shaft. This work was performed and stations were cut at the seventeenth and eighteenth levels, the latter being at the tunnel level.

There has been accomplished 1,614 feet of exploratory and development work at a cost of $4.12 per linear foot (labor and powder). In addition to the above should be added 183 feet of sinking the main Elkton shaft to the drainage tunnel level, the cost of which was $15.58 per linear foot (labor and powder).

The property produced on company account 11,180 net tons of ore carrying an average gold content of $10.67 per ton. This tonnage was all practically produced from the seventeenth level of the Elkton vein, which, compared with the tonnage from the next level above, shows a loss of $7.75 per ton. Further, the waste in the vein at the seventeenth level was 70 per cent, as against 55 per cent in the same vein at the sixteenth level, as is shown in the company's annual report for the year 1915.

Lessees operating in the mine and on the dumps shipped a total of 23,979 tons of ore of a gross value per ton of $6.90.

Exclusive of the amount charged off for depletion of ore in the property, operations for the year resulted in a net loss to the company of $14,955.

On October 31, 1916, the mine was closed in order to retimber 200 feet of the main shaft from the surface. * * *

After the completion of the retimbering work in question the mine resumed operations on a leasing basis, since which time no men have been employed underground on company account.

It should be noted that in all the development performed at the eighteenth level, which comprises some 580 feet, no commercial ores were encountered.

The Ida May group of claims, purchased by the company in 1911, on which work has been done by the company from year to year, was developed during the year 1916 by extending the Mountain Girl claim crosscut 390 feet. That work was temporarily abandoned because of the prevalence of carbon dioxide gas. * * *

The report of the Mary McKinney Co. for the calendar year 1916 shows that there were produced on company account 6,328 tons of ore, with a gross value of $131,265, and by lessees, 5,232 tons, with a gross value of $97,080. On account of the amount of development work done during the year and also because the ore in the stope between the eleventh and twelfth levels was not regular but in pockets and lenses, the net profit was not so large as for 1915. During the latter part of the year 1916 an examination was made of the Mary McKinney as to the question of future ore supply. Acting upon these suggestions development work proceeded early in 1917.

*Beacon Hill.*—Producing mines were the Banner, Raaler (C. K. and N.), El Paso, Gold Dollar, Mable M., and Prince Albert.

*Bull Hill.*—Producing mines were Blocks 7, 8, 9, School Section 16, Blue Bird, Dante, Dexter, Gold Sovereign, Modoc, Ramona, Stratton Estate mines (American Eagles, Orpha May, Specimen, War Eagle, Zenobia, etc.), and Trail.

The annual report for the United Gold Mines Co. for the year ending September 1, 1916, says:

The lessees on the W. P. H. mine are breaking ore * * * between the fourth and fifth levels and have some ore on the third level and have found signs of an ore body on the bottom level at a depth of 900 feet. These lessees have sunk the shaft 200 feet, but have only done 75 feet of development work on the first level opened, and 200 feet on the second level to which they have sunk the shaft, but are actively carrying on exploration for ore on each of these two levels. (Since the annual meeting these lessees have opened a body of ore on the bottom level * * * and in addition thereto have opened another promising ore body on that level. They are also shipping some ore from other parts of the mine.)

*Silver Tip.*—The lessees have opened a good body of ore in the Silver Tip claim about 40 feet long, from which they will probably ship four or five cars a month for several months.

*Deadwood Mine.*—The main shaft on this group of properties, consisting of 34 acres, is sunk to a depth of 700 feet, * * * but the bottom level of the mine has not disclosed, after extensive development, ore of merchantable value, and is in what is commonly called a "lean" zone or horizon. * * * Arrangements are being made with the Isabella Co. for driving a crosscut from their lowest level to a point under the Deadwood shaft, at a depth of 400 feet below the bottom thereof, which in its course will cut several of the veins which in the upper parts of the mine produced large quantities of good ore. If this development should show sufficient ore to justify it, the Deadwood shaft will be sunk to the required depth, otherwise the ore will be mined and hoisted through the Isabella shaft, under arrangements made with that company. There are two lessees working on this property, but with small success, so far.

*Trail group.*—In this group, consisting of 27 acres, Anderson & Benkelman have a lease on about 2 acres of the Trail claim to a depth of 1,500 feet and about six months ago opened an ore shoot on the 1,200-foot level, about 200 feet long and 5 feet wide, of 50 per cent shipping ore and having a gross value of about $30 a ton. They have opened this ore on the 1,100-foot level and are searching for it on the 1,000-foot level, and have also opened it on the thirteenth level where the shoot is about 30 feet long, and having a shipping value of $27 per ton. They are also sinking the shaft another 100 feet, with the hope of opening this ore on the 1,400-foot level. Their lease expires January 10, 1920. Another lessee operating on the north 600 feet of the Trail claim at a depth of about 500 feet has opened an ore shoot 150 feet long, from

which he has made some shipments showing that the coarse ore has a gross value of $10 per ton and the screenings a gross value of $40 per ton; this is a promising prospect. Two other lessees are working at different places on the Trail group, but so far have not encountered any ore bodies of importance.

*Damon group.*—The company spent $5,014 during the year searching for ore on the Damon group, encountering a small body which returned $267 gross value. * * * One lessee has been actively engaged in prospecting for ore on this group and has shipped six cars aggregating 252 tons, with a gross value of $3,931.94, which paid $584 royalties to the company.

All the other groups of property owned or controlled by this company have either been idle during the year or prospected by lessees without important results. * * *

During the present year (to Sept. 1) the lessees have produced and sold 10,783 tons having a gross value of $219,215.75 and a net return to the lessees of $124,850.04, and on which they paid the company $30,853.41 in royalties.

The lessees expended in development work and mining operations the sum of $106,700.

*Mines between Altman and Goldfield.*—The producing mines were the Burns, Christmas, Findley, Golden Cycle, Isabella, Mountain Beauty, Pharmacist, Shurtloff, Victor, and Vindicator.

The annual report of the Isabella Mines Co. for the calender year 1916 says:

During 1916 the Isabella Mines produced 19,377 tons of ore worth $412,962, of which lessees (30 sets) mined 16,573 tons, valued at $258,688. * * * Development covered 18,587 feet. The most important result was the discovery of rich ore on the bottom level of the Lee shaft. * * * The mill was operated since October on ore assaying $3 per ton. The recovery from 1,500 to 2,000 tons monthly was 70 per cent.[1]

The Vindicator Consolidated Gold Mining Co. in its annual report for 1916 says:

There has been mined during the past year 319,197 tons of crude ore, which have produced 119,130 tons of shipping ore of an average gold content of $19.27 per ton. The gross value of company shipments was $1,324,873; after deducting freight and treatment, the net receipts from the sale of ore amounted to $1,001,709. During the past year, lessees shipped 61,152 tons of ore of an average gold content of $15.876 per ton, the gross value of which was $970,857; and after deducting freight, treatment, and sampling charges, the net receipts were $642,411. The company received $226,231 net royalties from lease operations.

The net profits from the Golden Cycle mine, from the date of its purchase to the present, are approximately $900,000. While at the present time only a small proportion of the present ore reserves are contained within the area purchased, the possibilities of additional ore bodies in Golden Cycle ground are by no means exhausted. In addition, results of operations have demonstrated conclusively the necessity and value of the Golden Cycle shaft to the company, as its excellent mill site and better mechanical equipment make practicable a mill of large capacity, which would not be possible using only the Vindicator shaft, with its very limited hoisting facilities.

A map is presented showing in detail the location and tonnages of the various dumps on the property. You will note, from an examination of these figures, that there is an estimated tonnage of about 2,000,000 tons, divided as follows:

| | Short tons. |
|---|---|
| Hull City property | 351,826 |
| Vindicator property | 1,083,014 |
| Golden Cycle property | 789,375 |
| | 2,224,215 |

Of this amount about 200,000 tons is considered waste. The indications are that there will be a profit of from 50 cents to 75 cents a ton from the milling of these reserves.

[1] See Min. and Sci. Press, Feb. 17, 1917, p. 247.

A consideration of the ore reserves of your company, as shown by the consulting engineer's report, together with the results obtained from the flotation mill, lead your directors to the conclusion that the future successful operation of your property depends upon the economical mining and milling of a large tonnage of low-grade ore.

The development work on company account during the past year resulted in the addition of 36,260.9 tons to the ore reserves, as shown at the end of the year 1915. The tonnage added to the ore reserves during the past year is, in a measure, disappointing. No payable ore has, up to this time, been opened up on the twentieth level of the Golden Cycle shaft, and only a relatively small tonnage has been opened on the nineteenth level of the Vindicator shaft. The development work on these two bottom levels is, of course, relatively small, and only about 25 per cent of the known mineralized area has been prospected. Development work on these bottom levels has been, and will be, vigorously prospected to explore thoroughly all the territory. As you will note in the consulting engineer's report, his opinion coincides with ours in that there is no change in the present levels. The present situation is, in a large measure, a repetition of conditions that have arisen in the past, not only on our property, but in other properties in the Cripple Creek district, viz, continuous ore shoots extend for only limited depths and for one cause or another move from one zone of fissuring to another.

*Battle Mountain.*—Producing mines were the Ajax, Carbonate Queen, Coriolanus, Dead Pine, Granite, Gold Coin, Portland, Independence, and Strong.

The twenty-third annual report of the Portland Gold Mining Co. for the year ending December 31, 1916 (dated Feb. 19, 1917), says:

During the past year (from the Portland mine) 394,788 crude tons of ore and waste were mined and handled by company operations and lessees. After sorting, this yielded on company account 63,457 tons of shipping ore, which gave a gross return of $1,540,462, or $24.275 per ton. The production made by lessees, after sorting, was 21,007 tons, which give a gross return of $511,940, or $24.37 per ton. Of the remaining 310,323 tons, 150,442 tons were rejected from the No. 1 and No. 2 ore houses, 23,739 tons from ends of stopes, 13,494 tons from development work, and 31,031 tons from the dumps, making a total of 218,706 tons, which were treated at the Victor mill, having a gross value of $578,021, or $2.64 per ton. Of the remaining 91,618 tons, 5,062 tons of waste from the ore houses were delivered to the surface dumps, and the balance of 86,556 tons were used in the mine for stope filling. There was a decrease of 41 cents per ton in the value of the ore shipped on company account from the preceding year. The ore shipped by lessees for the same period shows an increase in value of $1.62 per ton. The ore milled at the Victor plant shows a decrease in value of 39 cents per ton, or 13 per cent for the year. This is accounted for by close sorting in the ore houses and less ore direct from the stopes. The tonnage milled from the mine was the largest in the history of the property.

Early in the year the No. 2 shaft was completed to the 1,900-foot level, 1,972.73 feet vertically below the surface. The cutting of a station and drifting on the No. 1 vein started in June. This vein has held its size and values and has been exposed for a distance of 1,050 feet. The West No. 1 vein has been developed 450 feet. The Hidden Treasure and Lee vein systems have not been explored. It will require a year's time to thoroughly develop this territory. There is every indication that it will be as productive as the levels above.

The extensive exploration work planned for the 1,700-foot level and commenced in 1914 is not completed. To date, 12,991 feet of drifting and crosscutting has been accomplished. There are two crosscuts to be driven, one 800 feet and the other 600 feet long, to finish the work as outlined. With the exception of the four known vein systems, but one new ore shoot has been found. This is in the northwestern part of the property and is making ore of shipping grade. There are several veins of low-grade material on this level that, with development, may or may not expose shipping ore.

The upper levels continue to yield considerable high-grade ore, but show a decrease from former years. It is not likely that new large ore bodies will be discovered in these old workings, but it is probable small stopes of rich ore will be found from time to time. More attention must be given the low-grade material and future revenue won from this source. The total development for

the year amounted to 18,263 feet. New ore exposed equals 5.8 tons for each linear foot of work, and 35 new stopes were opened.

The 107 leases, working a daily force of 87 men, produced 21,007 net tons of ore of gross value of $24.37 per ton, amounting to $511,340. The proceeds of the company from these shipments was $193,067. One hundred and five of the leases were operated on the split-check system and two on a royalty basis, and from the latter the company received $285 of the above proceeds.

The amount of development accomplished by lessees was 6,964 feet of drifts, crosscuts, and raises, not counting the work performed in stopes.

As the ground available to lessees has been thoroughly worked by the company, we can not look forward to any phenomenal strikes and can figure on lessees producing ore only from ends of ore shoots, stringers, etc., consequently it is a difficult matter to predict the production for 1917, but conditions at present indicate a fairly successful year. The territory under lease takes in the ground above the adit, 200, and 400 foot levels tributary to the No. 1 shaft.

The heading of the Roosevelt drainage tunnel is now within 1,500 feet of the west side of your property. Drainage from the tunnel has averaged 10,000 gallons per minute for the past year and has lowered the water level of the district 90 feet. This tunnel will cross the Portland property at an elevation of 8,112 feet above sea level and 164 feet vertically below the floor of the 1,900-foot level. Water disappeared from the bottom of the No. 2 shaft, 33 feet below the station floor, July 15, at an elevation above sea level of 8,241.6 feet. At the normal rate of drainage, 7½ feet per month, the water level should now be 77 feet below the floor of the 1,900-foot station. It will require one year to drain the remaining 64 feet to the twentieth level and to sink the No. 2 shaft to that point. * * *

With the 1,800 and 1,900 foot levels partly developed, it is safe to assume that the company's earnings from the mine will compare favorably with those of the past year. Lessees seldom have any great amount of ore in sight, so their earnings fluctuate. There should, however, be no very marked decrease for the year. Everything considered, 1917 should show a continuation of the past year's prosperity.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN MONTANA.

(MINES REPORT.]

By V. C. HEIKES.

## PRODUCTION.

### GENERAL STATEMENT.

Montana mines produced during the calendar year 1916 gold, silver, copper, lead, and recoverable zinc valued at $133,882,947. There were 513 producers. In 1915 there were 643 producers, and the output was valued at $82,912,254. The increase of $50,970,693, more than 61 per cent, in value in 1916 was mainly due to the increased output and higher price of copper, silver, and zinc. Silver Bow County, which includes the Butte or Summit Valley district, produced more than 21 per cent of the gold, nearly 91 per cent of the silver, 99 per cent of the copper, nearly 68 per cent of the lead, about 97 per cent of the zinc, and more than 95 per cent of the total value of the output from deep mines.

*Mine production of gold, silver, copper, lead, and zinc in Montana in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 643 | 6,129,924 | $5,004,195 | 14,378,437 | 267,231,014 | 13,756,356 | 187,146,895 | $82,912,254 |
| 1916 | 513 | 7,860,425 | 4,550,494 | 16,494,366 | 352,928,373 | 13,595,136 | 229,259,075 | 133,882,947 |
| Increase or decrease, 1916 | | +1,730,501 | −453,701 | +2,115,929 | +85,697,359 | −161,220 | +42,112,180 | +50,970,693 |

[a] Placer product included.

### ORE.

The total quantity of ore sold or treated was 1,730,501 tons more than in 1915, and the total average value per ton increased from $13.37 in 1915 to $16.94 in 1916. The average value per ton of the gold and silver contained in this ore increased from $1.85 to $1.87. Mines in Silver Bow County are credited with the largest output of ore, of which 6,150,644 tons, or more than 85 per cent, was copper ore; 627,503 tons, lead-zinc ore; 11,417 tons, dry or siliceous ore:

22 tons lead ore; 387,836 tons, zinc ore; and 32,413 tons, copper-zinc ore.

The total output of dry or siliceous ore was 523,842 tons, of which 498,082 tons were classified as gold ore, 999 tons as gold and silver ore, and 24,761 tons as silver ore. The largest part, or 332,055 tons, of dry or siliceous ore, together with 49,505 tons of old tailings, was treated by cyanidation, and 18,959 tons was treated by amalgamation. There were 112,873 tons shipped directly to the smelters for treatment, and 10,450 tons were treated at concentration mills. Phillips, Lewis and Clark, and Fergus counties, with 259,880 tons, 71,765 tons, and 65,977 tons of ore, respectively, were the largest producers of strictly siliceous ores. To Deer Lodge County there was credited 65,310 tons of dry or siliceous ore, of which 65,273 tons was oxidized iron ore. Some of this containing more than 20 per cent excess iron and a little gold was mined in the Georgetown district of Deer Lodge County, and a similar ore, of lower grade, was mined near Elkhorn, in Jefferson County. Iron sulphide ore, aggregating nearly 4,077 tons, containing nearly an ounce of gold per ton and a little silver and copper, continued to be mined in Broadwater County, near Radersburg.

The output of copper ore was 6,197,978 tons, of which 5,592,898 tons were of milling grade and produced 1,928,401 tons of concentrate averaging 36 cents in gold and 4.85 ounces of silver per ton and 7.52 per cent of copper, and having an average value per ton of $40.56. From 38,413 tons of copper-zinc ore and tailing there were 831 tons of copper concentrate produced, which averaged 61 cents in gold and 10.98 ounces of silver per ton and 9.31 per cent of copper, and had an average value per ton of $53.63. The copper ore of shipping grade amounted to 587,501 tons, largely sulphides, containing 19 cents in gold and 3.13 ounces of silver per ton and 4.46 per cent of copper, and having an average value per ton of $24.18.

Most of the lead ore produced, or 7,021 tons, was shipped directly to the smelters and contained $6.02 in gold and 25.55 ounces of silver per ton, 0.23 per cent of copper, and 14.56 per cent of lead, and had an average value per ton of $44.04. Lead concentrates were separated from lead-zinc ore, of which 682,107 tons were treated, and produced 6,683 tons of lead concentrate, averaging $2.10 in gold and 28.11 ounces of silver per ton, 0.35 per cent of copper, and 35.03 per cent of lead. Lead concentrates were also separated from zinc ore, of which 338,220 tons were treated and produced 923 tons of lead concentrate, averaging 99 cents in gold and 20.12 ounces of silver per ton, 1.52 per cent of copper, and 31.75 per cent of lead. The average value per ton of all lead concentrates was $70.02. Zinc concentrates recovered from zinc ore, lead-zinc ore, and copper-zinc ore aggregated 296,096 tons, averaging 56 cents in gold and 11.90 ounces of silver per ton, 0.58 per cent of copper, 0.78 per cent of lead, and 38.15 per cent of zinc, the total average value per ton being $114.56. Lead-zinc concentrates recovered from lead-zinc ore aggregated 3,926 tons, containing a trace of gold, 9.27 ounces of silver per ton, and 9.14 per cent of lead and 34.24 per cent of zinc, the total average value per ton being $110.49.

*Ore and metals produced in Montana in 1916.*

| Source of production. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Placers | 120 | ..... | 34,982.82 | 5,342 | ..... | ..... | ..... |
| Dry or siliceous ore | 202 | 523,842 | 135,427.26 | 1,175,791 | 380,364 | 42,759 | ..... |
| Copper ore | 84 | 6,197,978 | 38,235.21 | 11,226,034 | 348,645,332 | 12,338 | ..... |
| Lead ore | 102 | 7,231 | 2,066.39 | 180,601 | 35,812 | 2,064,037 | ..... |
| Zinc ore | 15 | 388,380 | 3,812.29 | 1,008,141 | 2,422,463 | 600,513 | 66,507,826 |
| Copper-lead ore | 7 | 1,696 | 485.20 | 87,520 | 176,833 | 759,540 | ..... |
| Lead-zinc ore | 7 | 702,885 | 4,924.58 | 2,759,410 | 1,111,436 | 10,113,307 | 158,886,914 |
| Copper-zinc ore | 2 | 38,413 | 196.40 | 51,327 | 156,133 | 2,642 | 3,864,335 |
| | ..... | 7,860,425 | 220,130.15 | 16,494,366 | 352,928,373 | 13,595,136 | 229,259,075 |

*Ore sold or treated in Montana in 1916, in short tons.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Beaverhead | 148 | 682 | 646 | ..... | 1,184 | ..... | ..... | 2,660 |
| Broadwater | 4,109 | 3,128 | 91 | ..... | ..... | ..... | ..... | 7,328 |
| Cascade | 398 | ..... | 1,549 | ..... | ..... | 58 | ..... | 2,005 |
| Deer Lodge | 65,310 | 3 | 375 | 28 | ..... | ..... | ..... | 65,716 |
| Fergus | 65,977 | 62 | 196 | ..... | ..... | ..... | ..... | 66,235 |
| Gallatin | ..... | 25 | ..... | ..... | ..... | ..... | ..... | 25 |
| Granite | 14,111 | 5,485 | 619 | 139 | ..... | ..... | 6,000 | 26,354 |
| Jefferson | 7,970 | 27,674 | 2,303 | 309 | 75 | 16,000 | ..... | 54,331 |
| Lewis and Clark | 71,765 | 365 | 184 | 68 | 60 | ..... | ..... | 72,442 |
| Lincoln | 327 | 1 | 15 | ..... | ..... | ..... | ..... | 343 |
| Madison | 21,625 | 1,711 | 647 | ..... | 71 | 40 | ..... | 24,094 |
| Meagher | ..... | 2,002 | ..... | ..... | ..... | ..... | ..... | 2,002 |
| Mineral | ..... | 5,596 | 157 | ..... | ..... | 39,284 | ..... | 45,037 |
| Missoula | 515 | 216 | ..... | ..... | ..... | ..... | ..... | 731 |
| Park | 10 | ..... | 22 | ..... | ..... | ..... | ..... | 32 |
| Phillips | 259,880 | ..... | ..... | ..... | ..... | ..... | ..... | 259,880 |
| Powell | 210 | 250 | 374 | ..... | 32 | ..... | ..... | 866 |
| Ravalli | ..... | ..... | ..... | ..... | ..... | 20,000 | ..... | 20,000 |
| Sanders | 70 | 134 | 31 | ..... | 274 | ..... | ..... | 509 |
| Silver Bow | 11,417 | 6,150,644 | 22 | 387,836 | ..... | 627,503 | 32,413 | 7,209,835 |
| | [a] 523,842 | 6,197,978 | 7,231 | 388,380 | 1,696 | 702,885 | 38,413 | 7,860,425 |
| Value per ton in gold and silver | $6.82 | $1.32 | $22.34 | $1.91 | $39.87 | $2.73 | $0.99 | $1.87 |

[a] Includes 498,082 tons of gold ore, 999 tons of gold and silver ore, and 24,761 tons of silver ore.

## GOLD.

The mine production of gold in Montana decreased from $5,004,195 in 1915 to $4,550,494 in 1916. Silver Bow County is credited with the largest total output, $973,052, from deep and placer mines. Madison County followed with $820,230, from deep and placer mines, the output of the placers amounting to $644,766, against $862,719 in 1915. The largest output of gold from deep mines came from Silver Bow and Lewis and Clark counties, followed by Deer Lodge, Fergus, and Phillips counties. At amalgamation and cyanidation plants $1,247,097 in gold was produced, or an average recovery of $3.11 per ton of ore and tailings treated. Ore treated at concentration mills produced concentrates containing $950,922 in gold, or 42 cents per ton. The crude ore shipped to smelters contained $1,625,414 in gold, or an average per ton of $2.29. Placer gold was produced in largest quantity in Madison County, chiefly the output of one company operating four dredges in Alder Gulch.

*Mine production of gold in Montana in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | | | | Total. |
|---|---|---|---|---|---|---|---|---|---|
| | | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | |
| Beaverhead | 35.80 | 10.68 | 15.26 | 152.82 | ..... | 58.81 | ..... | ..... | 273.37 |
| Broadwater | 165.64 | 3,707.22 | 53.50 | 64.14 | ..... | ..... | ..... | ..... | 3,990.50 |
| Cascade | ..... | 240.80 | ..... | 70.58 | ..... | ..... | 4.64 | ..... | 316.02 |
| Deer Lodge | ..... | 35,715.97 | 4.77 | 127.80 | ..... | ..... | ..... | ..... | 35,848.54 |
| Fergus | ..... | 20,929.93 | .07 | 1.23 | ..... | ..... | ..... | ..... | 20,931.23 |
| Granite | 216.62 | 5,594.78 | 646.62 | 11.56 | 10.81 | ..... | ..... | 1.96 | 6,482.35 |
| Jefferson | 46.92 | 3,289.73 | 519.87 | 378.05 | 20.00 | 6.00 | 596.86 | ..... | 4,857.43 |
| Lewis and Clark | 321.11 | 36,129.73 | 51.51 | 20.41 | ..... | 151.00 | ..... | ..... | 36,673.76 |
| Lincoln | 72.22 | 363.49 | 3.52 | 8.00 | ..... | ..... | ..... | ..... | 447.23 |
| Madison | 31,190.56 | 7,234.67 | 20.01 | 972.79 | ..... | 252.40 | 8.20 | ..... | 39,678.63 |
| Meagher | 2.32 | ..... | .63 | ..... | ..... | ..... | ..... | ..... | 2.95 |
| Mineral | 593.71 | ..... | 4.50 | ..... | ..... | ..... | ..... | ..... | 598.21 |
| Missoula | 120.55 | 216.09 | 2.28 | ..... | ..... | ..... | ..... | ..... | 338.92 |
| Park | 26.27 | 6.96 | ..... | ..... | ..... | ..... | ..... | ..... | 33.23 |
| Phillips | 4.89 | 19,942.01 | ..... | ..... | ..... | ..... | ..... | ..... | 19,946.90 |
| Powell | 1,099.95 | 260.59 | 6.62 | 257.00 | ..... | 7.00 | ..... | ..... | 1,631.16 |
| Ravalli | 773.08 | ..... | ..... | ..... | ..... | ..... | 208.59 | ..... | 981.67 |
| Sanders | 10.26 | 3.52 | 2.89 | ..... | ..... | 9.99 | ..... | ..... | 26.66 |
| Silver Bow | 302.92 | 1,781.09 | 36,903.16 | 2.01 | 3,781.48 | ..... | 4,106.29 | 194.44 | 47,071.39 |
| | 34,982.82 | [a]135,427.26 | 38,235.21 | 2,066.39 | 3,812.29 | 485.20 | 4,924.58 | 196.40 | 220,130.15 |

[a] Includes 131,175.61 ounces from gold ore, 176.45 ounces from gold and silver ore, and 4,075.20 ounces from silver ore

## SILVER.

Montana mines produced 16,494,366 ounces of silver, valued at $10,853,293 in 1916. The quantity produced was nearly 15 per cent greater than in 1915. From copper ore 11,226,034 ounces of silver was obtained, an average of 1.81 ounces per ton, and the ore mined in Silver Bow County was responsible for the largest increase in 1916. Jefferson County had the next highest increase in silver. Cyanidation and amalgamation mills yielded precipitates and bullion containing 243,164 ounces, concentration mills produced concentrates containing 13,142,845 ounces, and crude ore shipped to smelters contained 3,059,096 ounces.

*Mine production of silver in Montana in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | | | | Total. |
|---|---|---|---|---|---|---|---|---|---|
| | | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | |
| Beaverhead | 3 | 3,502 | 692 | 9,816 | ..... | 76,603 | ..... | ..... | 90,616 |
| Broadwater | 31 | 1,110 | 4,382 | 1,700 | ..... | ..... | ..... | ..... | 7,223 |
| Cascade | ..... | 26,096 | ..... | 67,615 | ..... | ..... | 4,940 | ..... | 98,651 |
| Deer Lodge | ..... | 33,977 | 1 | 2,177 | ..... | ..... | ..... | ..... | 36,155 |
| Fergus | ..... | 12,153 | 60 | 1,707 | ..... | ..... | ..... | ..... | 13,920 |
| Gallatin | ..... | ..... | 2 | ..... | ..... | ..... | ..... | ..... | 2 |
| Granite | 50 | 582,845 | 23,313 | 25,849 | 11,543 | ..... | ..... | 5,728 | 649,328 |
| Jefferson | 10 | 14,689 | 76,200 | 38,132 | 2,900 | 1,765 | 31,007 | ..... | 164,703 |
| Lewis and Clark | 52 | 95,678 | 386 | 3,520 | ..... | 1,999 | ..... | ..... | 101,635 |
| Lincoln | 6 | 57 | 28 | 212 | ..... | ..... | ..... | ..... | 303 |
| Madison | 4,869 | 29,431 | 718 | 7,847 | ..... | 647 | 403 | ..... | 43,915 |
| Meagher | ..... | ..... | 282 | ..... | ..... | ..... | ..... | ..... | 282 |
| Mineral | 29 | ..... | 1,420 | 9,227 | ..... | ..... | 65,735 | ..... | 76,411 |
| Missoula | 5 | 34 | 907 | ..... | ..... | ..... | ..... | ..... | 946 |
| Park | 3 | 2 | ..... | 611 | ..... | ..... | ..... | ..... | 616 |
| Phillips | 2 | 175,905 | ..... | ..... | ..... | ..... | ..... | ..... | 175,907 |
| Powell | 145 | 1,652 | 395 | 10,468 | ..... | 1,070 | ..... | ..... | 13,730 |
| Ravalli | 46 | ..... | ..... | ..... | ..... | ..... | 27,878 | ..... | 27,924 |
| Sanders | ..... | 2 | 1,493 | 1,397 | ..... | 5,436 | ..... | ..... | 8,328 |
| Silver Bow | 91 | 198,658 | 11,115,755 | 323 | 993,698 | ..... | 2,629,447 | 45,799 | 14,983,771 |
| | 5,342 | [a]1,175,791 | 11,226,034 | 180,601 | 1,008,141 | 87,520 | 2,759,410 | 51,527 | 16,494,366 |

[a] Includes 342,579 ounces from gold ore, 5,994 ounces from gold and silver ore, and 827,218 ounces from silver ore.

## COPPER.

In 1916 Montana produced 352,928,373 pounds of copper, valued at $86,820,380. This total represents an increase of 85,697,359 pounds in quantity and $40,054,953 in value in 1916. Silver Bow County, or practically the Butte district, contributed all the copper except 3,389,875 pounds. Mines in Jefferson County produced the next largest quantity, 852,857 pounds, followed in order by Broadwater, Granite, and Mineral counties. Crude ore of various kinds smelted in 1916 contained 52,959,218 pounds of copper, an average of 3.73 per cent. The sulphide copper ore of smelting grade predominated and contained 50,665,769 pounds, an average of 4.49 per cent, and the oxidized copper ores contained 1,716,550 pounds, or 3.56 per cent. Copper precipitates produced from mine waters and the washings from old tailings contained 6,098,901 pounds, against 5,645,441 pounds in 1915. Ore leached amounting to 6,160 tons contained 85,284 pounds of copper. Concentrates shipped to smelters averaging 6.56 per cent of copper contained 293,784,970 pounds, the bulk of which was from copper concentrates. The output of copper from the Butte or Summit Valley district increased from 265,999,832 pounds in 1915 to 349,532,636 pounds in 1916. From the annual printed report of the Anaconda Copper Mining Co.[a] the following paragraph is taken:

> The new copper electrolytic and furnace refineries at Great Falls were completed and began operating in March, 1916. The output of the electrolytic tank house during the year was 127,620,000 pounds of cathodes, 56,062,000 of which were melted into shapes in the new furnace refinery at Great Falls and the balance shipped to the plant of the Raritan Copper Works for melting. At the close of the year the electrolytic refinery was running at the rate of 16,000,000 pounds output per month, and the furnace refinery at the same rate, both plants exceeding their respective estimated capacities by about 1,000,000 per month. * * *.
>
> The leaching plant at Anaconda treated during the year 525,500.57 tons of tailings from the concentrator dump, from which there were produced 3,648.25 tons of cement copper.
>
> This output does not represent the capacity of the plant, as operations were curtailed on account of a shortage of sulphuric acid, the entire output of the sulphuric acid plant at Anaconda being more urgently required for the concentrating and zinc operations of the company.

*Mine production of copper in Montana in 1916, in pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Beaverhead | 457 | 116,335 | 7,257 | ..... | 102,083 | ..... | ..... | 226,132 |
| Broadwater | 25,170 | 675,372 | ..... | ..... | ..... | ..... | ..... | 700,542 |
| Cascade | ..... | ..... | 3,748 | ..... | ..... | 168 | ..... | 3,916 |
| Deer Lodge | 162,199 | 1,176 | 574 | ..... | ..... | ..... | ..... | 163,949 |
| Fergus | ..... | 8,218 | 62 | ..... | ..... | ..... | ..... | 8,280 |
| Gallatin | ..... | 1,486 | ..... | ..... | ..... | ..... | ..... | 1,486 |
| Granite | 66,994 | 412,411 | ..... | 1,187 | ..... | ..... | 12,757 | 493,349 |
| Jefferson | 7,091 | 783,444 | 17,221 | 7,500 | 5,759 | 31,842 | ..... | 852,857 |
| Lewis and Clark | 1,293 | 26,827 | 597 | ..... | 4,385 | ..... | ..... | 33,102 |
| Lincoln | ..... | 594 | ..... | ..... | ..... | ..... | ..... | 594 |
| Madison | 18,791 | 71,757 | 5,611 | ..... | 19,695 | 890 | ..... | 116,744 |
| Meagher | ..... | 236,545 | ..... | ..... | ..... | ..... | ..... | 236,545 |
| Mineral | ..... | 380,565 | ..... | ..... | ..... | ..... | ..... | 380,565 |
| Missoula | ..... | 41,321 | ..... | ..... | ..... | ..... | ..... | 41,321 |
| Powell | 237 | 25,595 | ..... | ..... | 2,125 | ..... | ..... | 27,957 |
| Ravalli | ..... | ..... | ..... | ..... | ..... | 16,038 | ..... | 16,038 |
| Sanders | ..... | 42,970 | 742 | ..... | 42,786 | ..... | ..... | 86,498 |
| Silver Bow | 98,132 | 345,820,716 | ..... | 2,413,776 | ..... | 1,062,498 | 143,376 | 349,538,498 |
| | [b] 380,364 | 348,645,332 | 35,812 | 2,422,463 | 176,833 | 1,111,436 | 156,133 | 352,928,373 |

[a] Anaconda Copper Mining Co. Ann. Rept. for year ending December 31, 1916.

[b] Includes 250,475 pounds from gold ore, 33,348 pounds from gold and silver ore, and 96,541 pounds from silver ore.

## LEAD.

The mine production of lead in Montana was 13,595,136 pounds, valued at $938,064, in 1916, against 13,756,356 pounds, valued at $646,549, in 1915. Of this output more than 67 per cent was derived from mines in Silver Bow County, which produced 9,195,082 pounds, against 7,936,121 pounds in 1915. The increase was due largely to the output of lead in lead-zinc ores, which were concentrated at the Elm Orlu and Butte Superior mines. The next largest output of lead, or 1,309,188 pounds, came from the mines in Mineral County, followed by Beaverhead County with 785,308 pounds. Lewis and Clark, Jefferson, and Mineral counties showed a decrease in lead output. Crude ore of all kinds shipped to the smelters contained about 22 per cent of the total lead (2,982,509 pounds), 10,593,035 pounds were contained in concentrates, and 19,592 pounds in old tailings shipped. Lead ore shipped to smelters contained 2,044,445 pounds of lead, an average of more than 14 per cent, and the lead concentrates contained 5,267,940 pounds, an average of more than 34 per cent. The zinc concentrate contained 4,603,517 pounds of recoverable lead. Two mines at Butte supplied most of this material.

*Mine production of lead in Montana in 1916, in pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Beaverhead | 2,873 | ..... | 208,431 | ..... | 574,004 | ..... | ..... | 785,308 |
| Broadwater | ..... | ..... | 46,480 | ..... | ..... | ..... | ..... | 46,480 |
| Cascade | 12,237 | ..... | 617,732 | ..... | ..... | 5,200 | ..... | 635,169 |
| Deer Lodge | ..... | ..... | 50,593 | ..... | ..... | ..... | ..... | 50,593 |
| Fergus | ..... | ..... | 93,351 | ..... | ..... | ..... | ..... | 93,351 |
| Granite | 578 | ..... | 72,489 | ..... | ..... | ..... | 2,642 | 75,709 |
| Jefferson | 11,799 | 12,338 | 410,825 | 9,600 | 11,454 | 223,744 | ..... | 679,760 |
| Lewis and Clark | 10,345 | ..... | 69,633 | ..... | 12,307 | ..... | ..... | 92,285 |
| Lincoln | ..... | ..... | 10,500 | ..... | ..... | ..... | ..... | 10,500 |
| Madison | 4,887 | ..... | 294,937 | ..... | 74,536 | 9,197 | ..... | 383,557 |
| Mineral | ..... | ..... | 91,680 | ..... | ..... | 1,217,508 | ..... | 1,309,188 |
| Park | ..... | ..... | 6,086 | ..... | ..... | ..... | ..... | 6,086 |
| Powell | ..... | ..... | 77,572 | ..... | 8,511 | ..... | ..... | 86,083 |
| Ravalli | ..... | ..... | ..... | ..... | ..... | 62,620 | ..... | 62,620 |
| Sanders | ..... | ..... | 4,637 | ..... | 78,728 | ..... | ..... | 83,365 |
| Silver Bow | 40 | ..... | 9,091 | 590,913 | ..... | 8,595,038 | ..... | 9,195,082 |
| | [a] 42,759 | 12,338 | 2,061,037 | 600,513 | 759,540 | 10,113,307 | 2,642 | 13,595,136 |

[a] Includes 19,239 pounds from gold ore and 23,520 pounds from silver ore.

## ZINC.

The mine production of recoverable zinc in Montana was 229,259,075 pounds, valued at $30,720,716, in 1916, against 187,146,895 pounds, valued at $23,206,215, in 1915. The bulk of the zinc output was from Silver Bow County, and smaller quantities were from Mineral, Jefferson, Ravalli, Granite, Lewis and Clark, Cascade, and Deer Lodge counties. The largest quantity of zinc was contained in the product of the Butte & Superior mine, at Butte, and amounted to 181,624,842 gross pounds, in concentrate having an average zinc content of 52.876 per cent. Practically all of this concentrate and that of the Elm Orlu property is shipped to eastern smelting plants. The Anaconda Copper Co. began operations on zinc ores with a comparatively small electrolytic plant at Anaconda. The company also completed its plant at Great Falls, designed to produce 35,000 tons of electrolytic spelter per annum.

With the Anaconda Copper Co. in the market for low-grade zinc ore, producers in different districts of Montana, Idaho, Washington, and Utah are arranging to ship, or have shipped, ores of this class. The material goes to the Washoe plant for concentration and the concentrates are leached at Great Falls. A tentative schedule has been drawn up for ore containing not less than 10 per cent of zinc. The company pays for 100 per cent of the zinc content at 1½ cents per pound, 80 per cent of the silver content at market price, 80 per cent of the gold content at market price, and 70 per cent of the copper content at 6 cents less than the market price. The treatment charge is $1.50 per ton. The schedule is based on the market price for zinc of 9 cents per pound.

*Mine production of recoverable zinc in Montana in 1916, in pounds.*

| County. | Zinc ore. | Lead-zinc ore. | Copper-zinc ore. | Total. |
|---|---|---|---|---|
| Cascade | | 19,106 | | 19,106 |
| Deer Lodge | 18,754 | | | 18,754 |
| Granite | 70,128 | | 18,935 | 89,063 |
| Jefferson | 44,200 | 854,148 | | 898,348 |
| Lewis and Clark | 43,318 | | | 43,318 |
| Madison | | 2,642 | | 2,642 |
| Mineral | | 3,114,170 | | 3,114,170 |
| Ravalli | | 488,532 | | 488,532 |
| Silver Bow | 66,331,426 | 154,408,316 | 3,845,400 | 224,585,142 |
| | 66,507,826 | 158,886,914 | 3,864,335 | 229,259,075 |

## MINING INDUSTRY.

The record of metal production in 1916, surpassing any previous year for silver, copper, and zinc, was the result of reopening many old mines in several districts, among them being several gold properties in Fergus County, which, however, did not produce enough of the precious metal to prevent a decrease in the gold output of the State. Both the November and the December outputs of copper at Butte were reduced on account of extreme cold weather and the inability of the railroads to handle the normal output, thus necessitating the closing of mines for several shifts. At the Washoe works, near Anaconda, approximately 5,000 men are employed and at the Great Falls works about 2,700 men. The great increase in the use of electricity at the mines in the vicinity of Butte, the new electrolytic zinc works at Great Falls, and the electrification of the Chicago, Milwaukee & St. Paul Railway from Harlowton to Avery, Idaho, caused the Montana Power Co. to increase the capacity of its Rainbow plant on the Missouri River to 10,000 kilowatts at a cost of $500,000.

## METALLURGIC INDUSTRY.

Fifty-four milling plants of various kinds operated in Montana during part or the whole of the year 1916, some of them only for short periods. Fourteen plants used the amalgamation process; 4 used amalgamation and concentration; 17 were cyanidation mills; 14 were concentration mills, of which 8 used oil-flotation equipment; 1 used concentration and cyanidation; 2 were copper leach-

ing plants; and 2 were copper precipitating plants that extracted copper from mine waters. Several small precipitating plants were operated by lessees, whose output was included with that of the lessor. The electrolytic zinc plant at Great Falls and the leaching plant for tailing at Washoe are added to the list. Of the 400,519 tons of ore and old tailings treated at gold and silver mills, 18,959 tons were treated by amalgamation and yielded 4,982.94 ounces of gold and 2,690 ounces of silver, or an average recovery of $5.43 in gold and 0.14 ounce of silver per ton. The ore treated by cyanidation aggregated 332,055 tons, which, with 49,505 tons of old tailings, yielded 55,345.33 ounces of gold and 240,474 ounces of silver, or an average recovery per ton for ore and old tailings of $3 in gold and 0.63 ounce of silver. The total value of the bullion recovered from ore and old tailings by both amalgamation and cyanidation was $1,407,099, as against the output in 1915, valued at $1,300,022. During 1916 there were 206 pounds of mercury, 13,305 pounds of potassium cyanide, and 190,249 pounds of sodium cyanide consumed in gold and silver mills. This represented 0.026 pound of mercury per ounce of gold and silver bullion and 0.011 pound per ton of ore treated. The consumption of cyanide was 0.69 pound per ounce of gold and silver bullion and 0.53 pound per ton of ore and tailings treated.

*Gold and silver produced at mills in Montana in 1916.*

| County. | Ore. | Bullion recovered from ore by— | | | | Total value. |
|---|---|---|---|---|---|---|
| | | Amalgamation. | | Cyanidation. | | |
| | | Gold. | Silver. | Gold. | Silver. | |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces* | |
| Broadwater | 56 | 145.31 | 41 | | | $3,031 |
| Cascade | 10 | 8.55 | 12 | | | 185 |
| Deer Lodge | 60 | 46.91 | 6 | | | 974 |
| Fergus | [a] 65,764 | | | [b] 18,861.11 | [b] 9,280 | 396,000 |
| Granite | 175 | 81.08 | 22 | [c] 135.15 | [c] 52 | 4,519 |
| Jefferson | [d] 430 | 95.37 | 36 | | | 1,995 |
| Lewis and Clark | [e] 52,807 | 2,980.85 | 2,131 | [f] 16,239.18 | [f] 47,971 | 430,280 |
| Lincoln | 327 | 363.49 | 57 | | | 7,552 |
| Madison | [g] 9,088 | 949.44 | 333 | [h] 141.86 | [h] 7,257 | 27,553 |
| Missoula | 515 | 216.08 | 34 | | | 4,489 |
| Park | 10 | 6.96 | 2 | | | 145 |
| Phillips | 221,670 | | | [i] 19,942.01 | [i] 175,905 | 527,983 |
| Powell | 77 | 88.90 | 16 | | | 1,849 |
| Sanders | | | | [j] 3.51 | [j] 2 | 74 |
| Silver Bow | 25 | | | 22.51 | 7 | 470 |
| | 351,014 | 4,982.94 | 2,690 | 55,345.33 | 240,474 | 1,407,099 |

[a] Also yielded 83 tons of concentrates.
[b] Includes bullion from 60 tons of old tailings.
[c] Produced from 180 tons of old tailings.
[d] Also yielded 35 tons of concentrates.
[e] Also yielded 13 tons of concentrates.
[f] Includes bullion from 10,325 tons of old tailings.
[g] Also yielded 468 tons of concentrates.
[h] Bullion from 660 tons of old tailings.
[i] Includes bullion from 38,210 tons of old tailings.
[j] Bullion from 70 tons of old tailings.

Mills in Montana equipped for the concentration of low-grade ore treated 6,629,675 tons, or more than 84 per cent of the total ore mined. The concentrates produced and smelted amounted to 2,238,167 tons, containing 46,000.87 ounces of gold, 13,142,845 ounces of silver, 293,784,970 pounds of copper, 10,593,035 pounds of lead, and 228,622,600 pounds of zinc, valued in all at $113,236,364, or an average value per ton of $50.59.

Crude ore directly smelted, 710,224 tons, contained 78,629.38 ounces of gold, 3,059,096 ounces of silver, 52,959,218 pounds of copper, 2,982,509 pounds of lead, and 636,475 pounds of zinc, valued in all at $16,957,348, or an average of $23.88 per ton.

The following tables give the quantity of material shipped from the concentration mills and of crude ore shipped to the smelters, with the metal produced, by counties, in 1916:

*Mine production of metals from Montana concentrates in 1916.*

**By counties.**

| County. | Ore to concentrating mills. | Concentrates produced. | | | | | | Total value of concentrates. |
|---|---|---|---|---|---|---|---|---|
| | | Quantity. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | |
| | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Fergus | | 83 | 527.30 | 1,374 | | | | $11,804 |
| Granite | 6,000 | 198 | 1.98 | 5,728 | 12,757 | 2,642 | 18,935 | 9,666 |
| Jefferson | 40,294 | 7,595 | 690.30 | 60,518 | 502,495 | 233,344 | 898,348 | 314,184 |
| Lewis and Clark | | 13 | 22.00 | 42 | 251 | | | 545 |
| Madison | 11,490 | 1,237 | 3,754.71 | 6,130 | 45,543 | 12,711 | 2,642 | 94,086 |
| Mineral | 43,844 | 5,531 | 4.50 | 60,415 | 339,328 | 1,100,496 | 2,661,105 | 555,843 |
| Ravalli | | 788 | 208.59 | 27,878 | 16,038 | 62,620 | 488,532 | 96,385 |
| Silver Bow | 6,528,047 | 2,222,724 | 40,791.51 | 12,980,760 | 292,868,558 | 9,181,222 | 224,553,038 | 112,153,851 |
| | 6,629,675 | 2,238,167 | 46,000.87 | 13,142,845 | 293,784,970 | 10,593,035 | 228,622,600 | 113,236,364 |
| **By kinds of concentrates.** | | | | | | | | |
| Dry or siliceous | | 1,307 | 3,578.54 | 7,015 | 10,888 | | | $81,269 |
| Copper | | 1,929,232 | 33,602.78 | 9,368,092 | 290,282,734 | 3,514 | | 78,268,631 |
| Lead | | 7,606 | 724.06 | 206,491 | 74,337 | 5,267,940 | | 532,614 |
| Zinc | | 296,096 | 8,092.49 | 3,524,850 | 3,417,011 | 4,603,517 | 225,934,295 | 33,920,060 |
| Lead-zinc | | 3,926 | 3.00 | 36,397 | | 718,064 | 2,688,305 | 433,790 |

*Mine production of metals from Montana crude ore shipped to smelters in 1916.*

**By counties.**

| County. | Quantity. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Beaverhead | 2,660 | 237.57 | 90,613 | 226,132 | 785,308 | | $174,349 |
| Broadwater | 7,272 | 3,679.55 | 7,151 | 700,542 | 46,480 | | 256,308 |
| Cascade | 1,995 | 307.47 | 98,639 | 3,916 | 635,169 | 19,106 | 118,612 |
| Deer Lodge | 65,656 | 35,801.63 | 36,149 | 163,949 | 50,593 | 18,754 | 810,207 |
| Fergus | 411 | 1,542.82 | 3,266 | 8,280 | 93,351 | | 42,520 |
| Gallatin | 25 | | 2 | 1,486 | | | 367 |
| Granite | 19,999 | 6,047.54 | 643,476 | 480,592 | 73,067 | 70,128 | 681,086 |
| Jefferson | 13,397 | 4,004.84 | 102,903 | 346,411 | 426,824 | | 265,165 |
| Lewis and Clark | 9,310 | 17,110.62 | 51,439 | 32,851 | 92,285 | 43,318 | 407,809 |
| Lincoln | 16 | 11.52 | 240 | 594 | 10,500 | | 1,266 |
| Madison | 2,856 | 3,642.06 | 25,326 | 71,201 | 370,846 | | 135,057 |
| Meagher | 2,002 | .63 | 282 | 236,545 | | | 58,389 |
| Mineral | 1,193 | | 15,967 | 41,237 | 208,692 | 453,065 | 95,761 |
| Missoula | 216 | 2.29 | 907 | 41,321 | | | 10,809 |
| Park | 22 | | 611 | | 6,086 | | 822 |
| Powell | 789 | 442.31 | 13,569 | 27,957 | 86,083 | | 30,888 |
| Sanders | 439 | 12.89 | 8,326 | 86,498 | 83,365 | | 32,777 |
| Silver Bow | 581,966 | 5,785.64 | 1,960,230 | 50,489,706 | 13,860 | 32,104 | 13,835,156 |
| | 710,224 | 78,629.38 | 3,059,096 | 52,959,218 | 2,982,509 | 636,475 | 16,957,348 |
| **By kinds of ore.** | | | | | | | |
| Dry or siliceous | 112,873 | 70,788.39 | 925,856 | 365,796 | 39,245 | | $2,165,233 |
| Copper | 587,501 | 5,285.25 | 1,841,496 | 52,382,319 | 12,338 | | 14,207,862 |
| Lead | 7,021 | 2,046.38 | 179,365 | 31,861 | 2,044,445 | | 309,230 |
| Zinc | 355 | 19.50 | 13,261 | 2,241 | 4,729 | 164,304 | 32,023 |
| Copper-lead | 1,696 | 485.22 | 87,520 | 176,833 | 759,540 | | 163,527 |
| Lead-zinc | 778 | 4.64 | 11,598 | 168 | 122,212 | 472,171 | 79,473 |

## PRODUCTION BY COUNTIES.

### GENERAL FEATURES.

A table follows showing the total of the State output by counties in 1916, and the mine production of each metal, with its total value; also a table showing production of ore and average value per ton by counties in 1915 and 1916, a table of the statistics of placer mines, and a review of the mining industry for each county and each producing mining district.

*Mine production of gold, silver, copper, lead, and zinc in Montana in 1916.*

| County. | Gold. | | | | | Silver. | |
|---|---|---|---|---|---|---|---|
| | Placers. | | Deep mines. | | Total value. | Quantity. | Value. |
| | Quantity. | Value. | Quantity. | Value. | | | |
| | *Fine ounces.* | | *Fine ounces.* | | | *Fine ounces.* | |
| Beaverhead | 35.80 | $740 | 237.57 | $4,911 | $5,651 | 90,616 | $59,625 |
| Broadwater | 165.64 | 3,424 | 3,824.86 | 79,067 | 82,491 | 7,223 | 4,753 |
| Cascade | | | 316.02 | 6,533 | 6,533 | 98,651 | 64,912 |
| Deer Lodge | | | 35,848.54 | 741,055 | 741,055 | 36,155 | 23,790 |
| Fergus | | | 20,931.23 | 432,687 | 432,687 | 13,920 | 9,159 |
| Gallatin | | | | | | 2 | 1 |
| Granite | 216.67 | 4,478 | 6,265.73 | 129,524 | 134,002 | 649,328 | 427,258 |
| Jefferson | 46.92 | 970 | 4,810.51 | 99,442 | 100,412 | 164,703 | 108,375 |
| Lewis and Clark | 321.11 | 6,638 | 36,352.65 | 751,476 | 758,114 | 101,635 | 66,876 |
| Lincoln | 72.22 | 1,493 | 375.01 | 7,752 | 9,245 | 303 | 199 |
| Madison | 31,190.56 | 644,766 | 8,488.07 | 175,464 | 820,230 | 43,915 | 28,896 |
| Meagher | 2.32 | 48 | .63 | 13 | 61 | 282 | 186 |
| Mineral | 593.71 | 12,273 | 4.50 | 93 | 12,366 | 76,411 | 50,279 |
| Missoula | 120.55 | 2,492 | 218.37 | 4,514 | 7,006 | 946 | 623 |
| Park | 26.27 | 543 | 6.96 | 144 | 687 | 616 | 405 |
| Phillips | 4.89 | 101 | 19,942.01 | 412,238 | 412,339 | 175,907 | 115,747 |
| Powell | 1,099.95 | 22,738 | 531.21 | 10,981 | 33,719 | 13,730 | 9,034 |
| Ravalli | 773.08 | 15,981 | 208.59 | 4,312 | 20,293 | 27,924 | 18,374 |
| Sanders | 10.26 | 212 | 16.40 | 339 | 551 | 8,328 | 5,480 |
| Silver Bow | 302.92 | 6,262 | 46,768.47 | 966,790 | 973,052 | 14,983,771 | 9,859,321 |
| | 34,982.82 | 723,159 | 185,147.33 | 3,827,335 | 4,550,494 | 16,494,366 | 10,853,393 |

| County. | Copper. | | Lead. | | Recoverable zinc. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Beaverhead | 226,132 | $55,629 | 785,308 | $54,186 | | | $175,091 |
| Broadwater | 700,542 | 172,333 | 46,480 | 3,207 | | | 262,784 |
| Cascade | 3,916 | 963 | 635,169 | 43,827 | 19,106 | $2,560 | 118,795 |
| Deer Lodge | 163,949 | 40,331 | 50,593 | 3,491 | 18,754 | 2,513 | 811,180 |
| Fergus | 8,280 | 2,037 | 93,351 | 6,441 | | | 450,324 |
| Gallatin | 1,486 | 366 | | | | | 367 |
| Granite | 493,349 | 121,364 | 75,709 | 5,224 | 89,063 | 11,934 | 699,782 |
| Jefferson | 852,857 | 209,803 | 679,760 | 46,903 | 898,348 | 120,379 | 585,872 |
| Lewis and Clark | 33,102 | 8,143 | 92,285 | 6,368 | 43,318 | 5,805 | 845,306 |
| Lincoln | 594 | 146 | 10,500 | 724 | | | 10,314 |
| Madison | 116,744 | 28,719 | 383,557 | 26,465 | 2,642 | 354 | 904,664 |
| Meagher | 236,545 | 58,190 | | | | | 58,437 |
| Mineral | 380,565 | 93,619 | 1,309,188 | 90,334 | 3,114,170 | 417,299 | 663,897 |
| Missoula | 41,321 | 10,165 | | | | | 17,794 |
| Park | | | 6,086 | 420 | | | 1,512 |
| Phillips | | | | | | | 528,086 |
| Powell | 27,957 | 6,877 | 86,083 | 5,940 | | | 55,570 |
| Ravalli | 16,038 | 3,945 | 62,620 | 4,321 | 488,532 | 65,463 | 112,396 |
| Sanders | 86,498 | 21,279 | 83,365 | 5,752 | | | 33,062 |
| Silver Bow | 349,538,498 | 85,986,471 | 9,195,082 | 634,461 | 224,585,142 | 30,094,409 | 127,547,714 |
| | 352,928,373 | 86,820,390 | 13,595,136 | 938,064 | 229,259,075 | 30,720,716 | 133,882,947 |

*Ore sold or treated, mines producing, and average value per ton of ores in Montana in 1915 and 1916.*

| County. | Ore sold or treated, 1916. | | Number of deep mines producing. | | Average value per ton.[a] | | Average value per ton in gold and silver.[a] | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Increase or decrease. | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 |
| | *Short tons.* | *Short tons.* | | | | | | |
| Beaverhead | 2,660 | + 1,145 | 13 | 23 | $64.58 | $65.54 | $32.31 | $24.26 |
| Broadwater | 7,328 | − 18,831 | 28 | 13 | 20.81 | 35.39 | 16.14 | 11.43 |
| Cascade | 2,005 | + 216 | 14 | 17 | 64.81 | 59.24 | 50.55 | 35.63 |
| Deer Lodge | 65,716 | + 178 | 12 | 13 | 13.96 | 12.34 | 13.60 | 11.64 |
| Fergus | 66,235 | + 16,711 | 7 | 12 | 9.61 | 6.80 | 9.59 | 6.67 |
| Gallatin | 25 | + 17 | 1 | 1 | 52.13 | 14.68 | ..... | .04 |
| Granite | 26,354 | + 10,340 | 33 | 31 | 35.36 | 26.38 | 34.06 | 21.12 |
| Jefferson | 54,331 | + 43,102 | 65 | 61 | 16.10 | 10.76 | 10.69 | 3.82 |
| Lewis and Clark | 72,442 | + 8,131 | 82 | 46 | 10.76 | 11.58 | 9.55 | 11.30 |
| Lincoln | 343 | − 34 | 2 | 4 | 24.54 | 25.70 | 17.89 | 23.17 |
| Madison | 24,094 | + 4,947 | 115 | 85 | 17.61 | 10.65 | 16.75 | 8.35 |
| Meagher | 2,002 | + 1,909 | 1 | 5 | 46.23 | 29.16 | .08 | .10 |
| Mineral | 45,037 | − 5,454 | 6 | 3 | 3.86 | 14.47 | 1.23 | 1.12 |
| Missoula | 731 | − 1,713 | 6 | 5 | 4.74 | 20.93 | 4.51 | 7.02 |
| Park | 32 | + 32 | ..... | 2 | ..... | 30.22 | ..... | 17.09 |
| Phillips | 259,880 | + 21,958 | 3 | 3 | 2.35 | 2.03 | 2.35 | 2.03 |
| Powell | 866 | − 227 | 32 | 18 | 36.37 | 37.80 | 28.91 | 23.00 |
| Ravalli | 20,000 | + 12,000 | 1 | 1 | 2.39 | 4.82 | .28 | 1.13 |
| Sanders | 509 | + 264 | 3 | 7 | 41.29 | 64.54 | 7.85 | 11.43 |
| Silver Bow | 7,209,835 | +1,635,730 | 58 | 43 | 13.85 | 17.69 | 1.28 | 1.50 |
| | 7,860,425 | +1,730,501 | 482 | 393 | 13.37 | 16.94 | 1.85 | 1.87 |

[a] Value per ton, placer product excluded.

*Number of producing placer mines and production in Montana in 1915 and 1916.*

| County. | 1915 | | | | | | 1916 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hydraulic, dry, and sluicing. | Dredging. | Drift. | Gold. | Silver. | Total value. | Hydraulic, dry, and sluicing. | Dredging. | Drift. | Gold. | Silver. | Total value |
| | | | | | *Fine ounces.* | | | | | | *Fine ounces.* | |
| Beaverhead | 5 | ..... | ..... | $684 | 6 | $687 | 4 | ..... | ..... | $740 | 3 | $742 |
| Broadwater | 11 | ..... | 1 | 5,752 | 43 | 5,774 | 6 | ..... | ..... | 3,424 | 31 | 3,444 |
| Cascade | 1 | ..... | ..... | 146 | 2 | 147 | ..... | ..... | ..... | ..... | ..... | ..... |
| Deer Lodge | 2 | ..... | ..... | 308 | 2 | 309 | ..... | ..... | ..... | ..... | ..... | ..... |
| Gallatin | 1 | ..... | ..... | 49 | ..... | 49 | ..... | ..... | ..... | ..... | ..... | ..... |
| Granite | 13 | ..... | 1 | 6,854 | 77 | 6,893 | 8 | ..... | 1 | 4,478 | 50 | 4,511 |
| Jefferson | 9 | ..... | ..... | 1,267 | 13 | 1,274 | 5 | ..... | ..... | 970 | 10 | 977 |
| Lewis and Clark | 34 | ..... | ..... | 9,422 | 133 | 9,489 | 17 | ..... | 2 | 6,638 | 52 | 6,672 |
| Lincoln | 6 | ..... | ..... | 2,527 | 11 | 2,533 | 5 | ..... | ..... | 1,493 | 6 | 1,497 |
| Madison | 10 | 1 | ..... | 862,719 | 7,240 | 866,390 | 7 | 1 | ..... | 644,766 | 4,869 | 647,970 |
| Meagher | 2 | ..... | ..... | 225 | 2 | 226 | 1 | ..... | ..... | 48 | ..... | 48 |
| Mineral | 12 | 1 | ..... | 12,389 | 24 | 12,401 | 15 | 1 | 2 | 12,273 | 29 | 12,292 |
| Missoula | 12 | ..... | ..... | 4,321 | 9 | 4,325 | 10 | ..... | ..... | 2,492 | 5 | 2,495 |
| Park | 3 | ..... | 2 | 2,367 | 19 | 2,377 | ..... | ..... | 1 | 543 | 3 | 545 |
| Phillips | 1 | ..... | ..... | 12 | ..... | 12 | 1 | ..... | ..... | 101 | 2 | 102 |
| Powell | 19 | ..... | 1 | 18,692 | 111 | 18,748 | 18 | ..... | 1 | 22,738 | 145 | 22,834 |
| Ravalli | 4 | ..... | ..... | 19,190 | 63 | 19,222 | 4 | ..... | 1 | 15,981 | 46 | 16,011 |
| Sanders | 3 | ..... | ..... | 632 | 5 | 634 | 2 | ..... | ..... | 212 | ..... | 212 |
| Silver Bow | 5 | ..... | ..... | 1,589 | 15 | 1,597 | 7 | ..... | ..... | 6,262 | 91 | 6,322 |
| Toole | 1 | ..... | ..... | 103 | ..... | 103 | ..... | ..... | ..... | ..... | ..... | ..... |
| | 154 | 2 | 5 | 949,248 | 7,775 | 953,190 | 110 | 2 | 8 | 723,159 | 5,342 | 726,674 |

## BEAVERHEAD COUNTY.

*Mine production in Beaverhead County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 18 | 1,515 | $17,064 | 65,733 | 125,988 | 467,644 | 33,136 | $98,527 |
| 1916 | 27 | 2,660 | 5,651 | 90,616 | 226,132 | 785,308 | ..... | 175,091 |
| Increase or decrease, 1916 | ..... | +1,145 | −11,413 | +24,883 | +100,144 | +317,664 | −33,136 | +76,564 |

[a] Includes placer production.

The output by 23 deep-mine operators was 1,145 tons more than that of 13 deep-mine operators in 1915. The total average value per ton increased from $64.58 in 1915 to $65.54 in 1916, and the gold and silver value decreased from $32.81 to $24.26 per ton. All the ore mined in 1916 was of shipping grade and contained $4,911 in gold, 90,613 ounces of silver, 226,132 pounds of copper, and 785,308 pounds of lead, valued in all at $174,349. The largest part, or 1,184 tons, was copper-lead ore, 682 tons was copper ore, 646 tons was lead ore, and 148 tons was dry or siliceous ore. Placer bullion produced contained $740 in gold and 3 ounces of silver, against a yield of $684 in gold and 6 ounces of silver in 1915.

*Ajax district.*—A small quantity of lead ore containing gold and silver and a little copper was produced from one property in 1916.

*Argenta district.*—Six producers of deep mines shipped 547 tons of ore containing $2,875 in gold, 8,299 ounces of silver, 5,328 pounds of copper, and 144,900 pounds of lead, valued in all at $19,645, or an average value per ton of $35.91. The largest producer was the Tilden property, from which lead sulphide ore, carrying gold, silver, and a little copper, was mined. The Midnight and Tuscarora properties were also producers of ore.

*Bald Mountain district.*—Only one producer reported the production of lead ore containing silver and a trace of copper.

*Bannack district.*—No ore was shipped or treated in the district during 1916. The reports received from three placer operators show a production of $640 in gold and 3 ounces of silver.

*Beaverhead district.*—This district, near the Idaho line, is reached by the way of Baker, Idaho, the post office and supply point. Only one producer, the Dark Horse, reported the production of copper sulphide ore carrying silver and gold. It is reported that bismuth has been found in the ore. The property is opened by a vertical shaft and has 400 feet of drifts.

*Big Hole district.*—The Montana Oreway property shipped two lots of ore carrying considerable lead, silver, and gold, and a little copper. This was the only deep-mine producer reporting in 1916. A little placer gold was also reported from one source.

*Blue Wing district.*—Five small shipments of ore, valued at $2,137 were made from this district in 1916. The principal production, consisting of silver ore, came from the New Departure property operated by lessees.

*Bryant district.*—Shipments of crude ore were made from four properties in 1916. The largest and most important production was the output of about 30 lessees on the holdings of one company, owning the Atlantis, Alta, True Fissure, Cleopatra, Cleve, and Ariadne claims. The ores mined were for the most part oxidized, but some contained galena. The sulphur content as a general rule is under 2 per cent. Altogether there were produced 1,343 tons of ore, containing $1,334 in gold, 77,733 ounces of silver, 115,625 pounds of copper, and 605,527 pounds of lead, valued in all at $122,707, or an average value per ton of $91.37.

*Elkhorn district.*—Development work carried on along the adit on the old Elkhorn property is expected to cut the vein 1,000 feet below the surface. One car of crude ore was shipped as a mill test in 1916. The company operating the property contemplates building a 100-ton mill in 1917.

*Nogo district.*—The Millionaire property, situated at Apex, shipped a small quantity of lead ore carrying silver and gold.

*Utopia district.*—Two properties were operated in 1916 the Ida & Chief group and the Indian Chief property. There were 54 tons of ore produced, containing copper with silver and a little gold, and having a total value of $1,451, or an average value per ton of $26.87.

*Saginaw district.*—This district, reached by way of Jackson, was very active during 1916. The operation of the Saginaw property, which produced copper ore, was worthy of note.

## BROADWATER COUNTY.

*Mine production in Broadwater County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 40 | 26,159 | $418,869 | 17,931 | 675,937 | 80,421 | $550,029 |
| 1916 | 19 | 7,328 | 82,491 | 7,223 | 700,542 | 46,480 | 262,784 |
| Increase or decrease, 1916 | ..... | −18,831 | −336,378 | −10,708 | +24,605 | −33,941 | −287,245 |

[a] Includes placer production.

Thirteen deep-mine operators reported the production of 18,831 tons less than was produced by 28 operators in 1915. The total average value per ton increased from $20.81 in 1915 to $35.39 in 1916, and the gold and silver value in this ore decreased from $16.14 to $11.43. The greater part of the ore, or 7,272 tons, was of shipping grade. There were treated at two milling plants 56 tons of ore, which yielded gold and silver bullion. The total ouput of the county was $82,491 in gold, 7,223 ounces of silver, 700,542 pounds of copper, and 46,480 pounds of lead, valued in all at $262,784. The yield of placer bullion amounted to $3,424 in gold and 31 ounces of silver, against $5,752 in gold and 43 ounces of silver in 1915.

*Backer district.*—The Confederate claim, a placer producer, and the operators on the Slim Jim lode, were producers of some gold and silver bullion. Gold in small pocket seams, reported to be found at the contact of slate and granite, was taken out in small quantities and milled in the 1-stamp battery.

*Beaver district.*—During 1916 development was carried on at the Joe Dandy property and a small quantity of ore containing gold and silver was shipped. There was also one lot of ore shipped from the Gleeson claim. Some placer gold was recovered from the Indian Creek property.

*Cedar Plains district.*—Seven deep mines and 1 placer yielded $75,496 in gold, 6,580 ounces of silver, 148,466 pounds of copper, and 35,705 pounds of lead, valued in all at $118,812. The average value per ton of the 6,210 tons of ore treated was $19.04. The most important producers were the Keating Gold, Copper King & Alaska, and Red Elephant properties. The output of the Keating property was not so large as in former years, and the property was reported to have been inactive during the greater part of the year.

*Hellgate district.*—In 1916 the Eclipse-Argo property was operated by the Castleton Copper Co., and ore carrying an average of 26 per cent of copper and 0.10 ounce of silver was shipped. The ore occurs in a fissure vein in shale and limestone. The principal mineral is chalcopyrite.

*Park district.*—Small lots of ore were produced from the Kent Co. and W. A. Clark properties. The ore contained lead with good values in silver and gold.

## CASCADE COUNTY.

*Mine production in Cascade County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 15 | 1,789 | [a] $12,248 | [a] 154,488 | 4,365 | 526,751 | ..... | $116,094 |
| 1916 | 17 | 2,005 | 6,533 | 98,651 | 3,916 | 635,169 | 19,106 | 118,795 |
| Increase or decrease, 1916 | ..... | +216 | −5,715 | −55,837 | −449 | +108,418 | +19,106 | +2,701 |

[a] Includes placer production.

Seventeen producers shipped 216 tons more ore in 1916 than was produced in the county by 15 operators in 1915. The total average value per ton of the ore decreased from $64.81 in 1915 to $59.24 in 1916, and the gold and silver value per ton from $50.55 to $35.63. The total output of the county amounted to $6,533 in gold, 98,651 ounces of silver, 3,916 pounds of copper, 635,169 pounds of lead, and 19,106 pounds of recoverable zinc, valued in all at $118,795. The greater part of the ore, or 1,549 tons, was lead ore, 398 tons was dry or siliceous in character, and 58 tons was classified as lead-zinc ore.

*Montana district.*—Many of the properties in the district were worked by lessees who shipped small quantities of ore. The most important production came from the Benton, Queen of the Hills, and Liberty groups; also from the Ripple property. Among the other producers were the Broadwater, London, Florence, Equator, Wright & Edwards, Black Bird, Big Seven, Morning Star, and Silver Belt properties.

## DEER LODGE COUNTY.

Thirteen deep mine operators reported the production of 65,716 tons of ore. This is an increase in 1916 of 178 tons and 1 operator.

The total value per ton decreased from $13.96 in 1915 to $12.34 in 1916, and the gold and silver value per ton from $13.60 to $11.64. The larger part of the ore, or 65,656 tons, was a highly oxidized ore of shipping grade, containing principally gold, valuable at the smelters chiefly for its fluxing quality. There was also a small quantity of ore yielding gold and silver bullion. No placer production was reported in 1916. In 1915 there was a placer production of $308 in gold and 2 ounces of silver.

*Georgetown district.*—The ore output of 8 producers amounted to 65,226 tons. Most of this production was from the Southern Cross mine and consisted largely of oxidized iron ores carrying small quantities of gold and silver and a little copper. The Holdfast, Oro Fino, and Short Shift properties contributed to the output.

*Heber district.*—The Spain mine was the principal producer of lead sulphide ore carrying gold and silver and a little copper.

*Lost Creek district.*—The Silver King claim was worked during the year and yielded a small quantity of silver ore containing a little copper and gold.

*Oro Fino district.*—From the Independence property a small quantity of gold ore containing a little silver was shipped to the smelter. This property is opened by a vertical shaft 100 feet deep and has an adit 550 feet long with 100 feet of drifts.

## FERGUS COUNTY.

*Mine production in Fergus County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 7 | 49,524 | [a] $472,806 | [a] 4,311 | 1,297 | 18,713 | $476,099 |
| 1916 | 12 | 66,235 | 432,687 | 13,920 | 8,280 | 93,351 | 450,324 |
| Increase or decrease, 1916 | | +16,711 | −40,119 | +9,609 | +6,983 | +74,738 | −25,775 |

[a] Includes placer production.

The output reported by 12 producers was 66,235 tons of ore, all of which, with the exception of 471 tons, was of milling grade, yielding gold and silver bullion. The ore shipped contained gold, silver, copper, and lead, and averaged $103.45 per ton.

*Cone Butte district.*—The Double Jack and Sutter properties produced small quantities of ore. The ore from the former property contained lead and silver, and that from the Sutter property contained copper with a little silver and gold.

*North Moccasin district.*—The two principal producers were the North Moccasin and Kendall properties,[1] from which ore was treated by cyanidation in 1916. The North Moccasin mine yielded 33,715 tons of ore averaging $8.65 per ton in gold and silver, against 47,038 tons averaging $9.80 in 1915. Extracts from the company's report follow:

The development work for the year was largely at the bottom of the mine. The 600 level was driven 1,000 feet toward the Kendall mine, on the vein, with no milling

[1] Barnes-King Development Co. Ann. Rept. for year ending Dec. 31, 1916.

values, and 1,682 feet of drifting and crosscutting was done in the vein below the ore body, which was the largest and best in the mine. The latter work, while not entirely unproductive, was very unsatisfactory, because it showed a broken condition of the vein, with spotted values.

During the last two months of the year, a small ore shoot was opened on the 500 level west, but it did not give much promise of making a large tonnage.

The 400 west stope was continued to within 50 feet of C tunnel, and if the ore continues on its rake to the west, there is still some 200 feet to the surface. This, together with small pillars being cleaned up from all over the mine, is the ore in sight.

At the Kendall mine 14,918 tons of ore was mined and milled, averaging $2.50 per ton.

*Warm Springs district.*—Seven deep mines sold or treated 17,343 tons of ore and a small quantity of tailings, from which was produced $138,249 in gold and 10,475 ounces of silver, valued in all at $145,142, or an average value per ton of $8.37. The principal producer was the Spotted Horse property, yielding bullion from its ores recovered by the cyanide process. The Maginnis & Cumberland mine, besides producing ore treated by the cyanide process, shipped a small quantity of crude ore directly to the smelters. The following notes [1] are of interest:

One of the first places to use the cyanide process in the United States was at Gilt-edge on the south side of the Judith mountains, in the early nineties; the process was not well understood at that time, and the extraction varied from 90 per cent down to practically nothing. As a result, part of the large tailing-pile contains nearly as much gold as when first mined. Turnbull, Caldwell, and Allen are reworking part of this material, said to average $1.50 per ton, in a small cyanide plant. They have no way of heating solutions in vats, however, so during cold weather operations are suspended.

The Spotted Horse, Maginnis, and Cumberland mines at Maiden are being regularly operated by lessees. Since the discovery of the ore body in the Cumberland last spring the lessees have produced $75,000 in gold, largely in ore shipped to Anaconda. A recent clean-up of the cyanide mill gave $7,000.

*Wolf Creek district.*—Lead ore carrying silver and a little gold was produced from the Yankee Girl claim in 1916. This property is situated on Wolf Creek. Notes [1] on the district follow:

The high price of metals has stimulated prospecting and development in the eastern part of the Little Belt mountains during the past summer, after many years of quiet. The principal work has been done on the Yankee Girl mine on Running Wolf Creek. The mine was located in 1894, and some rich ore was hauled by wagon to Great Falls, but the lower grade could not pay for such a long haul and little was done with the property until recently. At present 12 to 15 men are employed and several teams are engaged in hauling ore to Stanford, the railroad shipping point. The ore bodies on Running Wolf are replacement deposits in limestone near the contact with porphyry; they have proved to be small and pockety in the past, but an extensive ore body is now thought to have been discovered. Work is being done on adjoining claims, and even if the shoots prove small they will pay to mine and ship at present prices.

### GALLATIN COUNTY.

One deep mine reported the output of a small quantity of copper ore of shipping grade. No placer production was reported.

[1] Min. and Sci. Press, Dec. 2, 1916, p. 819.

## GRANITE COUNTY.

*Mine production in Granite County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 47 | 16,014 | $115,411 | 861,832 | 82,321 | 134,681 | ..... | $573,096 |
| 1916 | 40 | 26,354 | 134,002 | 649,328 | 493,349 | 75,709 | 89,063 | 699,782 |
| Increase or decrease, 1916 | ..... | +10,340 | +18,591 | −212,504 | +411,028 | −58,972 | +89,063 | +126,686 |

[a] Includes placer production.

The 31 deep-mine producers reported 10,340 tons of ore more than was reported by 33 producers in 1915. The total average value per ton decreased from $35.36 in 1915 to $26.38 in 1916, and the gold and silver value per ton from $34.06 to $21.12. The ore shipped contained gold, silver, copper, lead, and zinc and had an average value per ton of $34.06. There were 175 tons yielding bullion treated at gold and silver mills. At concentration mills 6,000 tons of ore were treated, yielding 196 tons of concentrate containing gold, silver, copper, lead, and zinc, and having a total average value per ton of $49.30. Nine placer operators reported the yield of $4,478 in gold and 50 ounces of silver, against $6,854 in gold and 77 ounces of silver from 14 placers in 1915.

*First Chance district.*—Reports from 5 deep-mine operators gave a production of 1,118 tons of ore, containing $70,378 in gold, 6,414 ounces of silver, and 46,645 pounds of copper, valued in all at $86,073, or an average value of $76.99 per ton. The reports of 3 placer producers show a production of $528 in gold and 2 ounces of silver. Two properties made important outputs, the Nancy Hanks and the Shamrock. Each of these produced ore containing high values in gold, with some silver and a little copper. Placer gold was reported as being produced from the summit between Elk Creek and Kayuse Gulch.

*Flint Creek district.*—Seventeen deep mine producers reported in 1916 the output of 15,415 tons of ore containing $42,627 in gold, 631,560 ounces of silver, 222,345 pounds of copper, 72,767 pounds of lead, and 70,128 pounds of recoverable zinc, valued in all at $527,309, or an average value per ton of $34.21. The output in 1915 amounted to 13,717 tons having an average value per ton of $35.28. The Granite Bi-Metallic was the most persistent and important producer in the region, followed by the Hope property, each yielding ores containing gold, silver, and copper. In addition to the regular output, the former property yielded a small quantity of oxidized zinc ore, which was shipped to the Anaconda zinc plant. The ore of the Combination mine, credited to this district, carried silver and a little copper. Other producers were the Black Mail, John Mitchell, Hobo, Maggie C., Pocahontas, Bay View, and Bonanza. Those shipping ore containing lead in addition to the other metals were the Coyle, McKay, Spawn Lode, and Young America claims.

*Rock Creek district.*—Lessees on several placer properties produced a small quantity of gold during a short season.

*South Boulder district.*—Seven deep-mine producers reported the mining of 6,592 tons of ore, containing $3,883 in gold, 6,951 ounces of silver, 36,077 pounds of copper, 2,942 pounds of lead, and 18,935 pounds of recoverable zinc, valued in all at $20,072, or an average value per ton of $3.04. The output in 1915 was 260 tons with an average value per ton of $26.99. The larger part of this output was of milling grade, yielding 196 tons of concentrates containing copper and zinc and a little lead. There were 282 tons shipped directly to the smelters. The remainder, 130 tons of crude ore and 180 tons of old tailings, was treated in gold and silver mills, yielding bullion. Only 1 placer operator reported production during the year. The operations were carried on in Princeton gulch and yielded a small quantity of gold and silver bullion. The Brooklyn property was the most active in the district. It is opened by an adit 1,000 feet long and has 2,500 feet of drifts. It is equipped with a 250-ton concentration plant and flotation unit built in 1916 operating on table tailings. The other producers were the Gold Reef, Mount Powell, North Star, Royal Gold, and Silver Hill properties.

## JEFFERSON COUNTY.

*Mine production in Jefferson County., Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 74 | 11,229 | $73,952 | 93,441 | 70,627 | 975,852 | 19,796 | $182,007 |
| 1916 | 66 | 54,331 | 100,412 | 164,703 | 852,857 | 679,760 | 898,348 | 585,872 |
| Increase or decrease, 1916 | ..... | +43,102 | +26,460 | +71,262 | +782,230 | −296,092 | +878,552 | +403,865 |

[a] Includes placer production.

Sixty-one deep-mine producers in 1916 reported 43,102 tons of ore more than was reported by 65 producers in 1915. The total average value per ton decreased from $16.10 in 1915 to $10.76 in 1916, and the gold and silver value per ton in this ore from $10.69 to $3.82. Most of the ore produced, or 40,294 tons, was of milling grade and yielded 7,595 tons of concentrates, which contained $14,270 in gold, 60,518 ounces of silver, 502,495 pounds of copper, 233,344 pounds of lead, and 898,348 pounds of recoverable zinc, valued in all at $314,184, or an average value per ton of $41.37. There were 13,397 tons of shipping ore, containing gold, silver, copper, and lead, valued in all at $265,165, or an average value per ton of $19.79. The greater part of the ore output (27,674 tons) was classified as copper ore and 16,000 tons were classified as lead-zinc ore. The remainder of the output consisted of 7,970 tons of dry or siliceous ore, 2,303 tons of lead ore, 309 tons of zinc ore, and 75 tons of copper-lead ore. The production of 5 placer operators amounted to $970 in gold and 10 ounces of silver, against a production of $1,267 in gold and 13 ounces of silver in 1915.

*Amazon district.*—Four deep-mine producers reported the production of 81 tons of ore, carrying gold, silver, copper, and lead valued at $2,346, or an average value per ton of $28.96. The producers

were the New Albany, Robert Emmett, Australia, Aurella, and Independent.

*Boulder district.*—Lessees of the Baltimore property were active in producing an important quantity of copper, iron, and lead sulphide ores. Besides the gold, silver, copper, and lead content, there was also some zinc recovered from the ores mined from the property. The Bland & Weaver property, situated on Little Boulder Creek, yielded copper ore assaying as high as 7 per cent of copper and 37 ounces of silver.

*Cataract (including Lowland) district.*—The reports received from 17 deep mines gave 18,715 tons of ore, containing $28,588 in gold, 67,897 ounces of silver, 126,299 pounds of copper, 432,508 pounds of lead, and 854,148 pounds of recoverable zinc, valued in all at $248,633, or an average value per ton of $13.29. In 1915 there were 1,190 tons of ore produced having an average value per ton of $27.31. The Comet property was the principal producer and yielded lead-zinc ores and lead. The larger part of the output from this property was milled and the zinc concentrates shipped to the zinc works at Anaconda. The next largest production came from the Crystal property, the ores of which yielded principally copper with lead and silver. Other producers of importance were the West Rumley, Ruby & Columbia, Uncle Sam, and Silver Hill.

*Colorado district.*—There was reported 23,985 tons of concentrating ore, yielding 5,158 tons of copper concentrate, which was shipped directly to the smelter, and 1,413 tons of crude ore, containing lead and copper. There were 25 tons of ore which produced a small quantity of gold bullion. All of this output was the production of 14 deep-mine producers. The entire output was valued at $193,937. All of the milling ore was from the Boston-Corbin property, which is equipped with a 200-ton concentrator and a 100-ton oil flotation unit treating table tailings. The mine is opened by a vertical shaft 1,050 feet deep and has an adit 2,000 feet long. The larger part of the shipping ore was from the Blue Bird property. The ore contained principally copper and silver, with one shipment of lead sulphide ore. Other producers contributing to the total were the Alta, Glenbeg, Hattie, McCornick, and Peter Lode properties. There were also some old tailings and slag shipped from Wickes.

*Elkhorn district.*—Seven deep mines produced 7,665 tons of crude ore, most of which was from the Swissmont-Moreau property. A cyanide mill was constructed on one of these properties in 1916, but it was not operated. Other producers shipping ore were the Elkhorn Queen, Golden Curry, and the Bulwer properties. The total output of ore was valued at $70,966, or an average value per ton of $9.26. In 1915 there were 4,675 tons produced in the district, having an average value per ton of $8.98. The Heagan and Dolcoath claims produced ore which was treated in a 10-stamp mill and yielded bullion and concentrate containing gold and silver. Both properties are opened by adit levels, 175 feet and 100 feet, respectively.

*Homestake district.*—The Nellie and the Mascot claims, operated by lessees, produced high-grade silver ore carrying some gold.

*Lump Gulch district.*—Five deep mines yielded 290 tons of crude ore of shipping grade containing $3,749 in gold, 7,497 ounces of silver, 2,704 pounds of copper, and 40,156 pounds of lead, valued in all at

$12,118, or an average value per ton of $41.79. One placer situated about 9 miles from Clancey produced a small quantity of gold dust. The principal ore producer was the Duluth-Montana. There was also some ore shipped from the Liverpool and King Solomon properties.

*McClellan Creek district.*—The Gold Bar property produced some gold ore carrying silver and copper. This ore was shipped directly to the smelter.

*Mitchell Gulch district.*—One property yielded four carloads of gold ore containing a little silver and a trace of copper. Some gold bullion was reported from a placer in the district.

*Whitehall district.*—There were 444 tons of ore reported by 7 producers, containing $471 in gold, 1,345 ounces of silver, 31,271 pounds of copper, and 35,370 pounds of lead, valued in all at $11,490, or an average value per ton of $25.88. All the ore, with the exception of 5 tons, which was milled, was shipped directly to the smelters. The principal producers were the Eighty-Acre mine and the Milburn property.

## LEWIS AND CLARK COUNTY.

*Mine production in Lewis and Clark County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Placers: | | | | | | | | |
| 1915 | 34 | ..... | $9,422 | 133 | ..... | ..... | ..... | $9,489 |
| 1916 | 19 | ..... | 6,638 | 52 | ..... | ..... | ..... | 6,672 |
| Deep mines: | | | | | | | | |
| 1915 | 82 | 64,311 | 533,160 | 159,412 | 16,907 | 1,562,330 | 13,600 | 692,056 |
| 1916 | 46 | 72,442 | 751,476 | 101,583 | 33,102 | 92,285 | 43,318 | 838,634 |
| Increase or decrease, 1916 | ..... | +8,131 | +215,532 | −57,910 | +16,195 | −1,470,045 | +29,718 | +143,761 |

The output of ore reported by 46 producers was 8,131 tons greater than was produced by 82 operators in 1915. The total average value per ton increased from $10.76 in 1915 to $11.58 in 1916, and the gold and silver per ton from $9.55 to $11.30. The greater part of the ore was of milling grade, which was treated principally by cyanidation and yielded gold and silver bullion containing $397,313 in gold and 50,102 ounces of silver, and had an average value per ton of $8.15. In addition to the bullion, there were some concentrates produced containing gold, silver, and copper. Crude ore shipped aggregated 9,130 tons and contained $353,708 in gold, 51,439 ounces of silver, 32,851 pounds of copper, 92,285 pounds of lead, and 43,318 pounds of zinc, valued in all at $407,809, or an average value per ton of $44.67. Most of the ore mined (71,765 tons) was dry or siliceous in character. There were also produced 365 tons of copper ore, 184 tons of lead ore, 68 tons of zinc ore, and 60 tons of copper-lead ore. The placer output of 19 producers amounted to $6,638 in gold and 52 ounces of silver, against $9,422 in gold and 133 ounces of silver in 1915.

*Bald Butte district.*—During 1916 Bald Butte tailings were treated in the 200-ton cyanide plant, in which the tailings are sluiced to the plant and classified, the sands are leached, and the slimes are agitated,

settled, and filtered. Some of the tailings were treated in the small plant at the St. Louis mine, which was taken over late in August and operated three weeks.

*Dry Gulch district.*—The output of 2 deep mines and 3 placers was valued at $30,775. There were 8,265 tons of ore mined, all of which with the exception of 5 tons, which was of shipping grade, was milled in a cyanide plant and yielded bullion. The principal producer was the Golden Messenger & Dandy property, on which there is a 50-ton cyanide plant. The property was worked until June. The placers producing were those in Oregon Gulch, New York Gulch, and Dry Gulch.

*Greenhorn district.*—Five deep mines and 3 placers produced an output valued at $7,409. There were 249 tons of ore produced, all of which, with the exception of 21 tons, yielded gold and silver bullion. The remainder was shipped directly to the smelter and contained gold, silver, copper, and lead. The deep-mine producers were the Roosevelt, Stem Winder, and Umatilla properties, and the placers were the Greenhorn and Evans & Jones.

*Helena district.*—Six deep mines produced 108 tons of milling ore, yielding gold and silver bullion, and 60 tons of crude ore containing copper and lead. The total value of the output was $7,567. The bullion production from four placers was $1,736 in gold and 14 ounces of silver. Some of the gold was taken from excavations on building sites in the city of Helena. The Yellow Boy mine was the principal producer of milling ore.

*Lincoln district.*—From 4 placer properties there was produced $1,692 in gold and 12 ounces of silver, with a total value of $1,700.

*Ottawa district.*—There was considerable activity at the Piegan-Gloster, Shannon, and Drumlummon mines. The principal production was from the first property, on which there is a 150-ton cyanide plant equipped for the all-slime treatment. According to the annual report [1] of the company, the mine and mill were operated continuously to June 8, when the mill was shut down for completing arrangements for all-slime treatment of Shannon and Gloster ores. During the last three months of 1916 the Gloster mill treated 174 tons of ore per day, all the ore being slimed with a saving of 95 per cent of the gold and 68 per cent of the silver. There were treated in 1916 22,478 tons of ore averaging $6.30 per ton. The Shannon property, under option to the Piegan-Gloster interests, shipped its first ore to the Gloster mill on August 10, and thereafter shipments were gradually increased to 100 tons a day. Development work was confined largely to the tunnel level, the main drift being driven 291 feet west on the vein. Ore reserves at the end of the year down to the 400 level were estimated at 26,000 tons.

The St. Louis Mining & Milling Co. has opened the Drumlummon mine. New mining and metallurgical plants have been provided and the output of the mine is 125 tons of ore daily.

*Owyhee district.*—The Easy Money and McCrea properties produced milling ore, yielding gold and silver bullion in 1916.

*Poorman district.*—One placer operator reported a small quantity of gold and silver bullion.

[1] Barnes King Development Co. Ann. Rept. for year ending Dec. 31, 1916.

*Scratch Gravel district.*—Six producers reported the output of 8,394 tons of ore, all of which was of shipping grade and contained $341,761 in gold, 38,246 ounces of silver, 13,771 pounds of copper, and 5,064 pounds of lead, valued in all at $370,665, or an average value per ton of $44.16 Most of the ore was taken from the Franklin mine which produces principally gold and silver. There was also production from the Scratch Gravel Gold and Helena Scratch Gravel properties.

*Seven Mile district.*—The Saginaw group yielded a small quantity of silver ore containing a little lead.

*Stemple district.*—From the Rover and Bachelor properties the ore mined was treated by amalgamation and cyanidation. Each property yielded gold and silver bullion in 1916

*Springhill district.*—The Skelly Gulch, Greenhorn, and St. Louis properties produced a small quantity of gold bullion These properties are situated about 9 miles from Austin, where the gravels are hydraulicked.

*Unionville district.*—The Whitlatch mine, with its 20-stamp mill and concentrator, was operated and yielded bullion and concentrates carrying gold and silver.

*Vaughn district.*—The district produced 5,768 tons of ore, most of which was milled and yielded bullion. There were 7 operators. There were also 472 tons of ore shipped directly to the smelter, yielding gold, silver, lead, zinc, and a little copper. The Porphyry Dike property, from which oxidized ores containing principally gold and silver were mined, was the principal producer. This ore was treated in a 20-stamp amalgamation mill. The mine is opened by an adit 1,250 feet long and has 1,400 feet of drifts and crosscuts. The other producers were the Crescent, Montana, Oden, San Juan, Stanton, and Woodrow Wilson.

*Wolf Creek district.*—A small quantity of silver ore, containing a little copper, was mined from the Silver Lode mine in this district, which is situated 2 miles south of Wolf Creek post office. There was also some copper ore shipped from the King Bee & Bear property.

## LINCOLN COUNTY.

Four deep-mine operators reported 343 tons of ore containing gold, silver, and lead, valued in all at $8,817, or an average value per ton of $25.70. The output of the placers reported by 5 producers amounted to $1,493 in gold and 6 ounces of silver. The placer production in 1915 amounted to $2,527 in gold and 11 ounces of silver.

*Libby district.*—On Libby, Howard, and West Fisher creeks there were several producers of placer gold. The largest output was reported to have been made from the Bear Creek placer. Other operators worked on the Howard Gulch, Nugget, and Standard Creek properties. The deep mines producing were the Annie and Lukens Hazle properties. The former produced gold and silver bullion and some tungsten concentrates from milling ore, and the latter yielded lead sulphide of shipping grade.

## MADISON COUNTY.

*Mine production in Madison County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Placers: | | | | | | | | |
| 1915 | 11 | ..... | $862,719 | 7,240 | ..... | ..... | ..... | $866,390 |
| 1916 | 8 | ..... | 644,766 | 4,869 | ..... | ..... | ..... | 647,970 |
| Deep mines: | | | | | | | | |
| 1915 | 115 | 19,147 | 274,293 | 91,446 | 18,051 | 283,453 | ..... | 337,137 |
| 1916 | 85 | 24,094 | 175,464 | 39,046 | 116,744 | 383,557 | 2,642 | 256,694 |
| Increase or decrease, 1916 | ..... | +4,947 | −316,782 | −54,771 | +98,693 | +100,104 | +2,642 | −298,863 |

Eighty-five deep-mine operators in 1916 reported 4,947 more tons of ore than was produced by 115 operators in 1915. The total average value per ton decreased from $17.61 in 1915 to $10.65 in 1916, and the gold and silver value per ton from $16.75 to $8.35. Most of the ore (11,490 tons) was treated at concentration mills, and yielded 1,237 tons of concentrates containing $77,617 in gold, 6,130 ounces of silver, 45,543 pounds of copper, 12,711 pounds of lead, and 2,642 pounds of recoverable zinc, with an average value per ton of $76.06. In addition to the bullion, there were concentrates produced containing gold and silver. There were 9,088 tons of ore treated at gold and silver mills, yielding bullion containing $22,559 in gold and 7,590 ounces of silver, and having an average value per ton of $3.03. There were 2,856 tons of ore shipped, containing $75,288 in gold, 25,326 ounces of silver, 71,201 pounds of copper, 370,846 pounds of lead, valued in all at $135,057, or an average value per ton of $47.29. Of the ore mined, 21,625 tons were classified as dry or siliceous ore, 1,711 tons as copper, 647 tons as lead ore, 71 tons as copper-lead ore, and 40 tons as lead-zinc ore. Placer bullion reported by 8 producers amounted to $644,766 in gold and 4,869 ounces of silver, against a placer output by 11 producers of $862,719 in gold and 7,240 ounces of silver in 1915.

*Alder Gulch district.*—In 1916, 11 operators reported 204 tons of ore of smelting grade. The ore contained gold, silver, lead, and a little copper, the total value of which was $6,694, or an average value per ton of $32.81. Much of this ore was mined by lessees. The reports from the placer operators showed a production of $644,213 in gold and 4,864 ounces of silver. The larger part of the placer output came from the Conrey placers, where 3 dredges were operated the entire year and 1 dredge during 7 months of the year. The average value per ounce of the gold bullion produced was $17.57.

*Lower Hot Springs district.*—Only 2 producers reported in 1916. Their production was 5 tons of lead ore containing gold and silver. The total value of the ore was $390.

*McCarthy district.*—A small quantity of lead ore containing silver was shipped from the Windy property in 1916.

*Mineral Hill district.*—Seven deep-mine operators reported the production of 8,895 tons of ore containing $44,165 in gold, 2,637 ounces of silver, 3,751 pounds of copper, valued in all at $46,823, or an average value per ton of $5.26. Of the ore produced, there were 8,801 tons yielding gold and silver bullion by amalgamation, and 468 tons

of gold and silver concentrates containing a little copper. The concentrates and 94 tons of crude ore containing gold, silver, and copper were shipped directly to the smelter. The principal producers were the Boss Tweed & Clipper, Galena, Pony, and Oregon properties.

*Norwegian district.*—Five producers shipped 66 tons of copper ore containing gold and silver amounting to $2,602, or an average value per ton of $39.42. The ore was produced principally from the Sunrise, Bonanza, Gold Hill, O. K., and Tag properties.

*Rabbit district.*—Ore aggregating 134 tons, containing $780 in gold, 1,572 ounces of silver, 4,500 pounds of copper, and 51,202 pounds of lead, valued in all at $6,454, was shipped directly to the smelters, with an average value per ton of $48.16. The Clifton, Marshall, Rochester, Polly Jane, and Rubicon claims were the principal producers.

*Ramshorn district.*—Three deep-mine and 4 placer operators reported the production of ore and bullion valued at $1,361. The principal deep mines operated in the district were the Cash Boy and Waters Tunnel. The placers were the Camp Bird, Ground Hog, California Gulch, and Holst.

*Sheridan district.*—Twelve deep mines produced 570 tons of ore, of which 274 tons were shipped directly to the smelters and the remainder milled, yielding gold and silver bullion and some concentrate. The total content of these ores was $10,835 in gold, 1,199 ounces of silver, 13,029 pounds of copper, 64,968 pounds of lead, and 2,642 pounds of recoverable zinc, valued in all at $19,666, or an average value per ton of $34.50. The output in 1915 was valued at $28,445. Among the producers were the Buckeye, Red Pine, Tamarack & Paymaster, Deutschland, Emma B., and Lone Tree properties.

*Silver Star district.*—Eight deep-mine operators produced 358 tons of ore, all of which, with the exception of 1 ton which yielded some gold and silver bullion, was shipped directly to the smelters. The total output in gold, silver, and copper was valued at $10,129. The Broadway, Edgerton, Hudson, King Fisher, and Silver King properties were the principal producers.

*Summit district.*—Five deep-mine producers reported the output of 125 tons of gold and silver ore, of which 121 tons was shipped directly to smelters and the remainder yielded gold and silver bullion. In addition to this output there were 660 tons of old tailings re-treated from the Easton Pacific property. Altogether the output was valued at $16,925, and had an average value per ton of $21.56. In 1915 the mines produced $68,538, or an average value per ton of $16.25. The other producers were the Elfleda, Homestake, Black Rock claims, and the Little Lode property.

*Tidal Wave district.*—In 1916, 21 producers reported the production of 11,852 tons of ore, which contained $92,436 in gold, 10,636 ounces of silver, 52,862 pounds of copper, and 240,357 pounds of lead, valued in all at $129,022, or an average value per ton of $10.89. The larger part (10,450 tons) was milled and yielded 668 tons of concentrates, which, with 1,402 tons of crude ore containing gold, silver, copper, and lead, was shipped to the smelters. The most important production came from the B. and H. mines. Of less importance were the Eleanor, Moffet, Mountain View, Hammerway, Keynote, Humming Bird, High Ridge, and Ella mines.

*Upper Hot Springs district.*—Only 2 producers reported in 1916. They shipped 78 tons of ore containing $4,258 in gold, 384 ounces of silver, and 1,420 pounds of copper, valued in all at $4,860, or an average per ton of $62.31.

*Washington district.*—The output of 2 deep-mine producers aggregated 80 tons containing gold and silver valued at $2,848.

*Wilmah district.*—The Bismark property was the only producer. The ore was treated in a concentrating mill, at which a flotation unit was installed. The concentrates, containing gold, silver, and copper, were shipped directly to the smelters with a small quantity of lead ore.

### MEAGHER COUNTY.

There were 2,002 tons of ore produced in 1916, which contained copper, silver, and gold, having an average value per ton of $29.16, against an output of 13 tons in 1915, having an average value per ton of $46.23. The ore shipped in 1915 contained copper and silver. A small placer production was reported by one operator, against $225 in gold and 2 ounces of silver reported by 2 operators in 1915.

*Castle Mountain district.*—The Copper Top and Copper Queen properties each produced some copper ore carrying very small values in gold and silver. Each of these properties is opened by a vertical shaft 100 feet and 150 feet deep, respectively.

*Musselshell district.*—The Copperopolis property was an important producer of copper ore carrying a little silver. A small quantity of ore was also produced from two other claims in the district.

### MINERAL COUNTY.

Three producers in 1916 reported 45,037 tons of ore, containing $93 in gold, 76,382 ounces of silver, 380,565 pounds of copper, 1,309,188 pounds of lead, and 3,114,170 pounds of zinc, valued in all at $651,605, or an average value per ton of $14.47. This output consisted largely of lead-zinc ore (39,284 tons), most of which was concentrated and yielded a concentrate which contained lead and zinc with some silver. The ore shipped aggregated 1,193 tons, and contained 15,967 ounces of silver, 41,237 pounds of copper, 208,692 pounds of lead, and 453,065 pounds of recoverable zinc, valued in all at $95,761, or an average value per ton of $80.27. The placer bullion reported by 18 producers amounted to $12,273 in gold and 29 ounces of silver, against a production of $12,389 in gold and 24 ounces of silver reported by 13 producers in 1915.

*Cedar Creek district.*—All the ore produced in the region was from the Intermountain property, formerly known as the Amador holdings. The larger part of the output was milled, but some copper ore was shipped directly to the smelter. This output with the production from 17 placer properties was valued at $106,862. The principal placer producers were the Cedar Creek, Deep Gulch, Meadow Creek, Ohio Gulch, Stockholm, C. B. & Q., and Windfall properties.

*Iron Mountain district.*—From January to August 17 the Iron Mountain Tunnel property was operated and produced ore, which was treated in the 250-ton concentrating mill on the property. This plant was equipped for wet concentration and treated the table tailings by oil flotation. The ores shipped consisted of silver-lead ore and lead-zinc ore. The ores milled gave a lead concentrate and a lead-zinc concentrate. The lead and zinc contained in the last-named product were paid for.

*Saltese district.*—A small shipment of lead ore was made from the Last Chance property in 1916.

### MISSOULA COUNTY.

Five deep mines produced 731 tons of ore. The principal part, or 515 tons, yielded gold and silver bullion, and 216 tons were shipped directly to the smelters. The total output contained $4,514 in gold, 941 ounces of silver, 41,321 pounds of copper, valued in all at $15,299, or an average value per ton of $20.93. There were 10 placers yielding gold and silver bullion amounting to $2,492 in gold and 5 ounces of silver.

*Coloma district.*—Gold and silver ore from the Dandy group was the only output reported from deep mines. Two placer operators reported a small quantity of gold and silver bullion.

*Copper Cliff district.*—Shipments of ore were made from the Leonard mine, near Bonita. This ore, which was partly oxidized, contained very small quantities of gold and silver, with from 6 to 10 per cent of copper.

*Nine Mile district.*—Only 1 deep mine reported the production of a small quantity of gold bullion, possibly recovered from some previous operation. Eight placers produced $2,225 in gold and 3 ounces of silver. In 1915 there was a production of $3,637 in gold and 5 ounces of silver reported. Among the placers producing in 1916 were the Chrysalis, Tom Tom, Pine Creek, Petty Creek, and Slide.

*Ravalli district.*—The McDonald property yielded some copper ore carrying principally silver with a little gold. The ore was shipped directly to the smelter.

*Woodman Creek.*—From the Lawyers Combination property a small quantity of oxidized copper ore was shipped. The property is opened by a vertical shaft 40 feet deep.

### PARK COUNTY.

*Emigrant Creek district.*—The Pittsburg placer yielded a small quantity of gold and silver bullion in 1916.

### PHILLIPS COUNTY.

*Little Rockies district.*—Three deep mines reported the treatment by cyanidation of 221,670 tons of ore and 38,210 tons of tailing, yielding gold and silver bullion valued at $527,984. The largest producer of ore was the Ruby Gulch property, and ore was also treated from the August and Beaver Creek mines.

### POWELL COUNTY.

*Mine production in Powell County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| Placers: | | | | | | | |
| 1915 | 20 | ..... | $18,692 | 111 | ..... | ..... | $18,748 |
| 1916 | 19 | ..... | 22,738 | 145 | ..... | ..... | 22,834 |
| Deep mines: | | | | | | | |
| 1915 | 32 | 1,093 | 22,109 | 18,728 | 9,160 | 139,188 | 39,749 |
| 1916 | 18 | 866 | 10,981 | 13,585 | 27,957 | 86,083 | 32,736 |
| Increase or decrease, 1916 | ..... | −227 | −7,082 | −5,109 | +18,797 | −53,105 | −2,927 |

Eighteen operators reported in 1916 the production or shipment of 866 tons of ore, which is 227 tons less than was produced by 32 operators in 1915. The total value per ton increased from $36.37 in 1915, to $37.80 in 1916, but the gold and silver value per ton decreased from $28.91 to $23.00. The bulk of the ore, or 789 tons, was of shipping grade, containing $9,143 in gold, 13,569 ounces of silver, 27,957 pounds of copper, and 86,083 pounds of lead, valued in all at $30,888, or an average value per ton of $39.15. Nineteen placer producers reported $22,738 in gold and 145 ounces of silver in 1916, against an output of $18, 692 in gold and 111 ounces of silver in 1915.

*Ontario district*—Six producers reported the mining of 210 tons of ore, all of which was of shipping grade, and contained gold, silver, copper, and lead, valued at $8,707, or an average value per ton of $41.46. In 1915 the total value was $24,993, and the average value per ton $37.57. The principal producers were the Black Jack, Centralia, Daylight, and Monarch claims.

*Ophir district.*—The output reported from 5 placers amounted to $762 in gold and 2 ounces of silver. The deep mines, of which there were 3, yielded 69 tons of ore containing gold, silver, and lead, and a very small quantity of copper from one property.

*Pioneer district.*—The Morning Glory and Pioneer properties were the only producers of ore in the district in 1916, both of which reported gold and silver, and the former a very small quantity of copper. The most extensive operations on the placers were made on the Pioneer, Upper Gold, and Friday properties.

*Snowshoe district.*—Two properties, the Minnie Healy and the Arnold, reported production, both yielding copper ore containing gold and silver.

*Washington Gulch district.*—Three deep mines and 6 placers produced an output valued at $2,937. The ore shipped amounted to 29 tons, and carried copper as well as gold and silver.

*Zozell district.*—From the Emery Consolidated and Emma Darling properties the production consisted of lead ore carrying gold and silver, mined by lessees.

### RAVALLI COUNTY.

*Curlew district.*—The Curlew jig tailings were reground and treated in pneumatic oil-flotation machines. The capacity of the mill was rated at 100 tons daily. Lead-zinc tailings gave some zinc concentrate and a few shipments of lead concentrate.

*Hughes Creek district.*—Altogether there was produced $15,999 from placer operators working in the district during 1916. The Wood placer continued to be the largest producer.

*Pleasant View district.*—A small quantity of bullion was recovered from placers in Schooner Gulch.

### SANDERS COUNTY.

Seven deep-mine producers reported the output of 509 tons of ore containing $339 in gold, 8,238 ounces of silver, 86,498 pounds of copper, and 83,365 pounds of lead, valued in all at $32,850, or an average value per ton of $64.54. Compared with 1915, the output was 264 tons greater, the total average value per ton increased from $41.29

to $64.54, and the gold and silver value per ton from $7.85 to $11.43. Of the output, 274 tons was classified as copper-lead ore, 134 tons as copper ore, 70 tons as siliceous ore, and 31 tons as lead ore.

*Camas Prairie district.*—The June Bug group, situated 3½ miles northeast of Camas Prairie, produced about 30 tons of ore carrying 5.7 per cent copper and a little gold and silver.

*Perma district.*—At the Exchange property a small quantity of ore was produced and shipped to Butte. The ore contained gold and silver.

*Spring Gulch district.*—From the King & Queen property copper-lead ore containing silver and a little gold was shipped to the smelter at East Helena.

*Trout Creek district.*—On Clark Fork River placers were in operation during part of the season and produced a small quantity of bullion. On the Canyon Creek property some tailing from earlier operations was re-treated and yielded gold and silver bullion.

## SILVER BOW COUNTY.

*Mine production in Silver Bow County, Mont., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 63 | 5,574,105 | $809,314 | 12,484,609 | 266,006,469 | 7,936,121 | 186,514,375 | $77,190,924 |
| 1916 | 50 | 7,209,835 | 973,052 | 14,983,771 | 349,538,498 | 9,195,082 | 224,585,142 | 127,547,714 |
| Increase, 1916 | | 1,635,730 | 163,738 | 2,499,162 | 83,532,029 | 1,258,961 | 38,070,767 | 50,356,790 |

[a] Includes placer production.

Practically all the ore produced in the county is from Butte or Summit Valley district. Forty-three deep-mine producers in the county reported 7,209,835 tons of ore. This was 1,635,730 tons more than was reported in 1915 by 58 operators. Most of this ore was produced by a few large operators. The remainder of the producers were lessees operating on various properties. The total average value per ton increased from $13.85 in 1915 to $17.69 in 1916, and the gold and silver value per ton in this ore from $1.28 to $1.50. The gold produced from both deep mines and placers increased in value from $809,314 in 1915 to $973,052 in 1916, the silver from $6,329,697 to $9,859,321, and the copper from $46,551,132 to $85,986,471. The expansion in the mining of lead-zinc ore also increased the value of lead from $372,998 in 1915 to $634,461, and that of zinc from $23,127,783 to $30,094,409. The total value of all metals increased from $77,190,924 in 1915 to $127,547,714 in 1916. The larger part of the ore produced, 6,528,047 tons, was concentrated at milling plants situated at Butte, Anaconda, and Great Falls. The product consisted of lead concentrates, zinc concentrates, copper concentrates, and lead-zinc concentrates, aggregating 2,222,724 tons and containing $843,235 in gold, 12,980,760 ounces of silver, 292,868,558 pounds of copper, 9,181,222 pounds of lead, and 224,553,038 pounds of zinc, valued in all at $112,153,851, or an average value per ton of $50.46. The crude smelting ore amounted to 581,966 tons and contained $119,599 in gold, 1,960,230 ounces of silver,

50,489,706 pounds of copper, 13,860 pounds of lead, and 32,104 pounds of zinc, valued in all at $13,835,156, or an average value per ton of $23.77. A small quantity of gold and silver bullion was produced from 25 tons of ore treated at a gold and silver mill. The ores mined were classified as 6,150,644 tons of copper ore, 627,503 tons of lead-zinc ore, 387,836 tons of zinc ore, 32,413 tons of copper-zinc ore, 11,417 tons of dry or siliceous ore, and 22 tons of lead ore. The placer output was $6,262 in gold and 91 ounces of silver, as against $1,589 in gold and 15 ounces of silver in 1915.

*Divide Creek district.*—Five deep-mine producers reported the shipment of 75 tons of ore carrying gold, silver, and copper, valued at $2,276. The placer output reported by one producer was very small.

*German Gulch district.*—Placers said to have been operated in the vicinity yielded $5,922 in gold and 91 ounces of silver in 1916. A large amount of work was performed in the Siberia and Central regions.

*Highland district.*—Some gold was produced by lessees on the property owned by the Butte Water Co.

*Butte or Summit Valley district.*—Since the beginning of activities in 1882 to the end of 1916, Silver Bow County, of which this district covers the largest part, has produced gold, silver, copper, lead, and zinc valued at $1,344,306,757, divided as follows: Gold, $28,699,212; silver, $213,763,873; copper, $1,029,210,359; lead, $1,730,866. In 1905 the production of zinc began, and to the end of 1916 the value amounted to $70,902,447. The values given above are for 1,388,-324.34 ounces of gold, 313,092,399 ounces of silver, 7,001,917,705 pounds of copper, 33,812,344 pounds of lead, and 730,639,271 pounds of recoverable zinc. A statement of the figures by years may be seen in Mineral Resources for the year 1913.

The Anaconda Copper properties [1] produced 5,582,076.52 tons of ore and 7,080.96 tons of precipitate, or a total of 5,589,157.48 tons, against a total in 1915 of 4,383,339.73 tons. At the Washoe reduction works at Anaconda there were treated 5,193,572.64 tons of ore and other cupriferous material, and at the Great Falls plant 813,495.53 tons. Of this quantity, 5,273,065.96 tons of ore were produced from company mines, 724,355.35 tons of ore were either purchased from or treated for other companies, and 9,646.86 tons of precipitates and cleanings came from the old works at Anaconda and Butte. This material produced 331,893,273 pounds of fine copper, 11,837,-769.23 ounces of silver, and 92,099.182 ounces of gold, of which 307,395,092 pounds of fine copper, 10,790,705.67 ounces of silver, and all of the gold was produced from the mines of the company. The following paragraph is taken from the company's annual report:

> The zinc plants at Anaconda and Great Falls treated for all companies during the year 196,680.21 tons of ore and other zinciferous material, of which amount 142,224.62 tons of ore were produced by company mines and 54,455.59 tons were purchased from other companies. At Anaconda there were produced during the year 8,320,522 pounds of electrolytic zinc and at Great Falls 12,585,917 pounds, or a total of 20,906,439 pounds.

The Emma mine, under lease to the Anaconda Copper Company,[2] is mentioned in its annual report as follows:

> The Emma shaft was dewatered to the 800-foot level, the old workings cleaned out and repaired, and prospecting work instituted, resulting in the opening up on the

[1] Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] Anaconda Copper Co. Ann. Rept. for year ending Dec. 31, 1916.

800-foot level of the mine of a large body of ore carrying good values in zinc, lead, and silver. During the year this mine produced 13,029.52 tons of ore, chiefly from development work. The ore was concentrated at the zinc concentrator of your company at Anaconda, and the concentrates obtained therefrom were shipped to and treated by the electrolytic zinc plant at Great Falls. The Emma shaft is being sunk below the 800-foot level, and a crosscut is being extended southerly on the 1,600-foot level of the Original mine, which should cut the Emma vein approximately 700 feet below the 800-foot level of the Emma, within a comparatively short time.

In 1916 the North Butte Mining Co.[1] shipped to the smelter 544,365 dry tons of ore and 89 dry tons of precipitate. Of this output, 49,252 tons were first class ore, 423,118 tons second class, and 71,995 tons third class. The output contained 24,498,181 pounds of copper, 1,047,063 ounces of silver, and 1,712 ounces of gold. During the latter part of 1916 there were mined 1,625 tons of zinc ore, containing 412,953 pounds of zinc and 2,510 ounces of silver. Dividends paid during 1916 amounted to $1,075,000.

The Butte and Superior mine[2] produced 627,370 tons of milling ore in 1916, or about 20 per cent more than in 1915. The receipts from spelter, zinc and lead concentrates, and residues were $14,625,321.81, or an average per ton of ore treated of $23.31. The average mining cost was $4.794 and the milling cost $2.138 per ton. Dividends were paid in 1916 amounting to $9,490,429.94 against $4,908,115.13 in 1915. The following extracts are taken from the company's report:

Important extensions of ore bodies were disclosed on practically all levels from and including the 700 to the 1,800. * * * All of the developments on the 1,700 and 1,800 foot levels were executed during the latter part of the year. On the 1,700-foot level the total length of development is about 550 feet along the vein, the footage on either side of the shaft being approximately equal. The width of ore body so far disclosed varies widely from an average of 16 feet in certain places, to 65 feet in others. Developments on the 1,800-foot level were also quite satisfactory in disclosing ore bodies of extent and grade fully up to expectations based upon conditions above. The grade of ore on the bottom levels is as to zinc contents about the same as the average for the mine, but the silver content is slightly lower. * * *

Estimates of ore reserves as of December 31 show 1,044,850 tons containing an average of 17.7 per cent zinc and 5.65 ounces silver. * * *

The total ore mined for the year was 626,803 tons at an average cost of $4.50 per ton, exclusive of taxes, or $1.14 more than the average cost for the previous year. This difference is entirely accounted for by difference in labor and supply costs. * * *

The total ore milled for the year was 627,370 tons, the increase over the previous year being about 105,000 tons, or approximately 20 per cent. The average contents of the ore as to the two principal metals was 15.55 per cent zinc and 6.57 ounces of silver, a reduction in zinc of about 1½ per cent, and in silver of about 1 ounce per ton, as compared to 1915. The decrease in metal content was due entirely to mining material of lower grade than had been previously included as ore, and for the reason that the returns from such material under the relatively high price of zinc prevailing were nearly as great as would result from the handling of average grade ores under normal spelter prices. The mill recovery for the year averaged 93.1 per cent of the zinc contents, an increase of not quite 1 per cent above the result for the previous year, notwithstanding greater tonnage and lower grade of ore treated. The larger tonnage of ore milled served as an offset to increased cost of labor and supplies to the extent that the milling costs were only slightly above those of 1915, but the combined cost of mining and milling increased to $6.34 per ton, exclusive of taxes, as compared to $5.11 per ton for the previous year. The total production of zinc concentrates for the year was 171,747 tons and at times it was difficult to find smelting capacity to accommodate the output. The entire tonnage was, however, disposed of to six different smelting companies, shipments being distributed among as many as a dozen smelting plants. Spelter sales made during the year were in excess of the year's production.

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[1] North Butte Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] Butte & Superior Mining Co. Fifth Ann. Rept., for year ending Dec. 31, 1916.

*Crude ore treated and concentrates produced at Butte-Superior mill in 1916.*

| Ore and product. | Quantity (tons). | Gold. | | Silver. | |
|---|---|---|---|---|---|
| | | Total content. | Average per ton. | Total content. | Average per ton. |
| | | *Ounces.* | | *Ounces.* | |
| Crude ore, milled | 627,370 | 6,618.817 | 0.01055 | 4,126,938.00 | 6.571 |
| Zinc concentrate | 171,747 | 5,539.600 | .0323 | 3,699,950.74 | 21.544 |
| Lead concentrate | 5,470 | 226.734 | .0415 | 150,060.70 | 27.433 |

| Ore and product. | Copper. | | Lead. | | Zinc. | |
|---|---|---|---|---|---|---|
| | Total content. | Average per ton. | Total content. | Average per ton. | Total content. | Average per ton. |
| | *Pounds.* | *Per cent.* | *Pounds.* | *Per cent.* | *Pounds.* | *Per cent.* |
| Crude ore, milled | 2,390,416 | 0.190 | 15,487,518 | 1.2343 | 195,083,557 | 15.547 |
| Zinc concentrate | 1,861,713 | .542 | 9,955,691 | 2.898 | 181,624,842 | 52.876 |
| Lead concentrate | 38,556 | .352 | 4,099,977 | 37.477 | 1,523,363 | 13.925 |

The Elm Orlu mined 500 tons of zinc-silver ore per day. Alterations have been made in its Timber Butte milling plant, which will soon be in shape to treat double the present output. Copper-bearing slimes from the old Butte Reduction Works which are being put through the flotation department bring the mill feed up to 800 tons daily. A large quantity of copper ore is shipped directly from the mine, and zinc concentrate, lead concentrate, and copper concentrate are the results of the milling operations.

The Pittsmont mine [1] produced 60,688 tons of first-class ore in 1916 containing an average of 6.11 per cent of copper, against an output in 1915 of 59,427 tons averaging 6.38 per cent. The second class ore, 149,117 tons in 1916, averaged 2.56 per cent of copper, against 71,107 tons averaging 2.62 per cent in 1915. The cost of mining was $5.46 per ton against $4.37 the previous year. At the Dutton property ore bodies between the 800 and 600 levels on No. 6 vein were nearly exhausted. The flotation plant, completed shortly before the beginning of the year, was operated continuously and is being further enlarged to re-treat impounded tailing. Both the smelter and concentrator operated at capacity.

There were produced from the Tuolumne property [2] 25,374 tons of ore containing 1,403,999 pounds of copper, 76,245 ounces of silver, and 189.57 ounces of gold. Nearly all of this ore was shipped to Anaconda for treatment at the Washoe concentrator, as only a few tons were of smelting grade. The following paragraph is taken from the company's annual report:

> All of the available ore has been mined in the stopes between the 2,400-foot level and the 1,800-foot level. A raise has been driven from the 2,600-foot level to the 2,400-foot level and the 2,600 stope is being worked between the first and twelfth floors. The ore in the 2,600-foot stope is bunchy, but generally of good grade and withal better than the ore body in the 2,400 stopes.
>
> During the years 1909 to 1912 exceptionally high-grade ore was produced from the 1,200, 1,400, and 1,600 foot levels and due to the low copper prices of that period low-grade ores could not be worked at a profit. With copper selling during the past

[1] East Butte Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] Tuolumne Copper Co. Ann. Rept. for year ending Dec. 31, 1916.

year from 24 cents to 32 cents per pound it was considered advisable to reopen and explore the old workings on these upper levels, as it was thought that considerable ore now of commercial grade had been left in these stopes as filling. On the 1,400-foot level the drift on the vein to the east of the main crosscut has been opened for its entire length to the east end line a distance of 350 feet. Above this level the filling is being mined and produces ore running from 2 per cent to 3 per cent copper. This stope is being worked from the first to the eighth floors and not to exceed one-third of the available tonnage has been mined during the past year.

The Main Range mine [1] produced 446 tons of first and second class ore averaging 2.47 per cent copper. This mine is being developed by the Tuolumne Copper Co. under arrangement with the Butte Main Range Copper Mining Co.

The Butte-Detroit Co., owning the Ophir mill, which has a capacity of 150 tons, has ordered flotation equipment. It was expected that this plant would be operated as a custom mill, but negotiations are under way with the Davis-Daly to supply zinc ore until such time as the Butte-Detroit develops enough ore in the Ophir property to keep the mill at work. At the Davis-Daly property there are several drifts in ore, which is said to be 6 to 10 feet wide and to average 30 per cent of zinc and 12 ounces of silver per ton. Flotation tests on the ore indicate that a 53 per cent zinc concentrate can be made with a recovery of 95 per cent. The low iron content makes the ore desirable for treatment by flotation.

[1] Tuolumne Copper Co. Ann. Rept. for year ending Dec. 31, 1916.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN UTAH.

(MINES REPORT.)

By V. C. HEIKES.

## PRODUCTION.

### GENERAL STATEMENT.

Utah mines in 1916 produced ore and a little mill and placer bullion containing gold, silver, copper, lead, and zinc valued at $89,268,684, an increase of $34,163,614, compared with 1915. There were 310 lode producers and 8 placers, as against 229 lode producers and 5 placers in 1915. More than 66 per cent of the total value was for copper, an increase of $26,265,247 in 1916. Gold decreased from $3,609,109 in 1915 to $3,574,947 in 1916, and silver increased in value from $6,242,795 to $8,720,498. Lead increased in both quantity and value, its value being $13,902,815, or $4,504,345 more than in 1915. The value of the recoverable zinc increased from $3,012,238 to $3,962,719 in 1916. The placer output of gold increased from $958 in 1915 to $1,250 in 1916.

*Mine production of gold, silver, copper, lead, and zinc in Utah in 1915–16.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 234 | 10,451,445 | $3,609,109 | 12,313,205 | 187,671,188 | 199,967,437 | 24,292,240 | $55,105,070 |
| 1916 | 318 | 13,920,643 | 3,574,947 | 13,253,037 | 240,275,222 | 201,490,075 | 29,572,528 | 89,268,684 |
| Increase or decrease, 1916. | | +3,469,198 | −34,162 | +939,832 | +52,604,034 | +1,522,638 | +5,280,288 | +34,163,614 |
| 1864–1916 | | | 89,764,177 | 352,541,394 | 1,715,488,260 | 3,797,078,199 | 170,667,738 | [b]816,827,182 |

[a] Includes small placer production.
[b] The total, by years, to the end of 1913, appears in Mineral Resources, 1913, pt. 1, p. 366, 1914.

Utah mines have produced altogether since the year 1864 gold, silver, copper, lead, and zinc valued at $816,827,182. This includes $89,764,177 in gold, $260,682,018 in silver, $279,339,396 in copper, $173,362,958 in lead, and $13,678,633 in zinc. Dividends paid by 20 producers in 1916 amounted to the sum of $24,376,569. In the history of the State dividends paid to stockholders of mining property, representing about 85 mines, have amounted to $152,774,801.

ORE.

In 1916 there were sold or treated in Utah 13,920,643 tons of ore containing recoverable metals valued at $89,268,684 (placer production included), an increase of 3,469,198 tons, compared with the production of 1915. The total average value per ton was $6.41 in 1916, against $5.27 in 1915, and the gold and silver value per ton decreased from 94 cents to 88 cents. Considerable old mine-dump material containing low metal values and an increased quantity of low-grade disseminated copper ore were produced in 1916.

The output of dry or siliceous ores increased from 61,976 tons in 1915 to 89,363 tons in 1916. This classification includes 1,308 tons of siliceous gold ores, averaging $10.49 in gold and 1.19 ounces of silver per ton. Gold and silver mixed ores, dry or siliceous in character, aggregated 4,337 tons and averaged per ton $5.39 in gold, 8.80 ounces of silver, 3.12 pounds of copper, and 21.82 pounds of lead. The siliceous silver ores mined in 1916 by 40 producers amounted to 83,718 tons and averaged per ton $1.81 in gold, 13.31 ounces of silver, 16.84 pounds of copper, and 1.81 pounds of lead, against 36,958 tons produced by 18 producers in 1915, which averaged $2.51 in gold, 24.64 ounces of silver, 11.66 pounds of copper, and 27.40 pounds of lead. The Grand Central mine in the Tintic district was the heaviest producer of silver ore, followed by the Iron Blossom and Chief Consolidated mines. The Ontario mine at Park City was also an important shipper of silver ore.

The copper ore mined by 107 producers amounted to 12,676,152 tons, which contained 18 cents in gold and 0.21 ounce of silver per ton, 0.91 per cent of copper, and averaged $4.78 a ton in value. Comparison with ore of similar character produced in 1915 shows that the quantity increased 3,239,702 tons, the gold and silver content decreased slightly, and the copper content was nearly the same. However, the total average value was only $3.63 per ton in 1915. Of the copper ore mined, the larger part, or 11,943,713 tons, was from the low-grade disseminated deposits. This ore produced 559,836 tons of copper concentrates, which were smelted. There were 732,680 tons of copper ore smelted directly, of which 580,548 tons were sulphide ore, assaying $1.62 in gold and 1.69 ounces of silver per ton, and 1.88 per cent of copper, and valued in all, per ton, at $11.99; and 152,132 tons were oxidized ore, assaying $2.85 in gold and 7.64 ounces of silver per ton, and 2.67 per cent of copper, valued in all, per ton, at $21.

There was more lead ore mined than in 1915. In 1916 the output of 180 producers aggregated 665,217 tons and averaged $1.04 in gold and 12.20 ounces of silver per ton, 0.54 per cent of copper and 11.97 per cent of lead, and $28.26 in total value per ton. Of this output 454,396 tons of sulphide and oxidized ores in about equal quantities were shipped directly to the smelters, the total quantity averaging $1.24 in gold and 16.05 ounces of silver per ton, 0.59 per cent of copper, and 14.84 per cent of lead, and $35.18 in value per ton. Of the lead ores, 192,042 tons were concentrated, yielding 70,795 tons of lead concentrate averaging 0.084 ounce of gold and 11.12 ounces of silver per ton, and 1.23 per cent of copper and 16.12 per cent of lead, and $37.34 in total value per ton. From the lead-zinc ore milled, 269,335 tons produced 94,192 tons of lead concentrate averaging 0.17 ounce of gold and 10.68 ounces of silver per ton, and 0.52 per cent of

copper, 19.74 per cent of lead, and $40.34 in total value per ton. The zinc concentrates saved from the lead-zinc ore milled aggregated 18,433 tons and averaged 0.006 ounce of gold and 4.61 ounces of silver per ton, 0.069 per cent of copper, 1.05 per cent of lead, and 38.03 per cent of recoverable zinc. There were also 6,042 tons of lead-zinc concentrate produced, averaging 0.056 ounce of gold and 17.58 ounces of silver per ton, 0.87 per cent of copper, 7.59 per cent of lead, and 30.78 per cent of recoverable zinc.

Zinc ore shipped from 32 properties in 1916 aggregated 18,400 tons, against 34,320 tons from 34 producers in 1915. Of this quantity, 16,889 tons was ore of smelting grade and 1,500 tons were estimated to have been leached at one experimental plant. There were shipped to the smelter 11 tons of old tailings from Stockton. The first-class zinc ore averaged 25.07 per cent of recoverable zinc, with a little silver and lead. Of this product, 16,869 tons were oxidized or mixed carbonate and silicate ores, averaging 25.06 per cent of recoverable zinc and 20 tons were sulphide ore, averaging 31.09 per cent of recoverable zinc.

There were 30 lead-zinc producers in 1916 who reported 278,840 tons of ore and 183,026 tons of old tailings re-treated. The latter yielded 6,042 tons of lead-zinc concentrates, which averaged $1.15 in gold, 17.58 ounces of silver per ton, 0.87 per cent of copper, 7.59 per cent of lead, 30.78 per cent of zinc, and $109.98 in value per ton. There were 9,505 tons of lead-zinc ore shipped to smelters, averaging 15.61 per cent of recoverable zinc and 8.18 per cent of lead, valued at $53.25 per ton.

Copper-lead ore, most of it oxidized or carbonates, increased from 5,329 tons produced by 10 mines in 1915 to 9,645 tons produced by 19 mines in 1916. Of this ore, 9,592 tons was of smelting grade and averaged 89 cents in gold and 15.09 ounces of silver per ton, 2.90 per cent of copper, and 8.79 per cent of lead, and $37.23 in value per ton.

Concentrates of all kinds produced in Utah in 1916, including those heretofore mentioned, aggregated 749,303 tons, contained more than 40 per cent of the gold, against about 34 per cent in 1915; nearly 19 per cent of the silver, against 20 per cent in 1915; more than 84 per cent of the copper, against 85 per cent; more than 30 per cent of the lead, against more than 31 per cent; and about 60 per cent of the zinc against more than 61 per cent in 1915. In 1916 the recoverable metal content of the concentrates was valued at $59,571,419, or a total average value per ton of $79.50, as against a total value in 1915 of $35,193,022, or a total average value per ton of $59.01.

Crude ore of all kinds shipped directly to the smelters represented more than 9 per cent of the total output and produced more than 59 per cent of the gold in 1916, as against 65 per cent in 1915; nearly 80 per cent of the silver, against 79 per cent; more than 15 per cent of the copper, against nearly 15 per cent; 68.8 per cent of the lead, against 67.7 per cent; and 38.7 per cent of the zinc, against 39 per cent in 1915. In 1916 the total value of the crude ore shipped to smelters was $29,202,373, or an average value per ton of $22.79, as against a total value in 1915 of $19,721,027, or an average value per ton of $20.58.

At mills using cyanidation and amalgamation 0.18 per cent of the total gold and a negligible quantity of silver was recovered from 1,423 tons of ore. The value of the gold and silver recovered from ore and tailings was $6,613, or $4.65 per ton. In 1915 the recovery of gold and silver from ores given similar treatment was valued at $32,003, or an average value per ton of $2.37.

*Ore and metals produced in Utah in 1916.*

| Source of production. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Placers | 8 | ..... | $1,250 | 2 | ..... | ..... | ..... |
| Dry or siliceous | 49 | 89,363 | 186,577 | 1,153,993 | 1,426,917 | 246,028 | ..... |
| Copper | 107 | 12,676,152 | 2,344,114 | 2,633,402 | 229,960,014 | 6,540 | ..... |
| Lead | 180 | 665,217 | 693,243 | 8,118,264 | 7,212,843 | 159,260,831 | ..... |
| Zinc | 32 | 18,400 | ..... | 2,914 | ..... | 230,877 | 8,865,582 |
| Copper-lead | 19 | 9,645 | 8,717 | 145,439 | 559,954 | 1,696,276 | ..... |
| Lead-zinc | 30 | 461,866 | 339,046 | 1,199,023 | 1,115,494 | 40,049,523 | 20,706,946 |
| | | 13,920,643 | 3,574,947 | 13,253,037 | 240,275,222 | 201,490,075 | 29,572,528 |

*Ore sold or treated in Utah in 1916, in short tons.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead. | Lead-zinc. | Total. |
|---|---|---|---|---|---|---|---|
| Beaver | 359 | 203,824 | 19,160 | 497 | ..... | 52,301 | 276,141 |
| Box Elder | 300 | 7,570 | 1,833 | 4,112 | ..... | 1,392 | 15,207 |
| Cache | ..... | 59 | 20 | 2 | ..... | ..... | 81 |
| Garfield | 30 | ..... | ..... | ..... | ..... | ..... | 30 |
| Grand | ..... | 15 | ..... | ..... | ..... | ..... | 15 |
| Iron | 373 | ..... | 238 | ..... | ..... | ..... | 611 |
| Juab | 76,876 | 115,324 | 155,287 | 4,748 | 78 | 468 | 352,781 |
| Millard | ..... | 20 | 20 | ..... | ..... | ..... | 40 |
| Morgan | ..... | 8 | 92 | ..... | ..... | ..... | 100 |
| Piute | 103 | 31 | 192 | ..... | ..... | ..... | 326 |
| Salt Lake | 148 | 12,343,729 | 277,219 | 1,594 | 7,493 | 201,478 | 12,831,661 |
| San Juan | ..... | 68 | ..... | ..... | ..... | ..... | 68 |
| Sevier | ..... | 9 | ..... | ..... | ..... | ..... | 9 |
| Summit | 7,221 | ..... | 82,214 | 20 | ..... | 144,390 | 233,845 |
| Tooele | 823 | 4,910 | 112,080 | 4,758 | 2,074 | 50 | 124,695 |
| Uinta | ..... | 5 | ..... | ..... | ..... | ..... | 5 |
| Utah | 2,318 | 431 | 12,693 | 2,669 | ..... | ..... | 18,111 |
| Wasatch | 797 | ..... | 4,169 | ..... | ..... | 61,787 | 66,753 |
| Washington | 15 | 149 | ..... | ..... | ..... | ..... | 164 |
| | [a]89,363 | 12,676,152 | 665,217 | 18,400 | 9,645 | 461,866 | 13,920,643 |
| Value per ton in gold and silver | $10.61 | $0.32 | $0.07 | $0.10 | $10.82 | $2.44 | $0.88 |

[a] Includes 1,308 tons of gold ore, 4,337 tons of gold and silver ore, and 83,718 tons of silver ore.

## GOLD.

The mine production of gold reported from Utah in 1916 was valued at $3,574,947, a decrease of $34,162, compared with 1915. The largest part of the gold was contained in ores produced in Salt Lake County and amounted to $2,513,096, against $2,516,844 in 1915. Juab County ranked next, with $856,474, against $910,354 in 1915. Bingham district produced $2,490,158 and Tintic district $855,454; in 1915 these outputs were, respectively, $2,507,477 and $916,775. Tooele County mines were credited with $18,882, against $15,433 in 1915. Placer gold was produced in Emery, Garfield, Grand, San

Juan, and Uinta counties and amounted in value to $1,250, against $958 in 1915. Ores treated in mills equipped for amalgamation produced $4,848 in gold in 1916 from 703 tons of ore mined in Beaver, Box Elder, Garfield, and Washington counties. Cyanidation was carried on in Iron and Tooele counties and produced $1,538 in gold from ore treated. The gold extracted by amalgamation averaged $6.90 a ton of ore treated, as against $13.97 a ton treated in 1915; and by cyanidation, $2.14, as against $0.76. Concentrates of copper, lead, and zinc, and a small quantity of siliceous concentrate contained $1,433,992 in gold, against $1,220,041 in 1915. Copper concentrates contained the largest quantity of gold, or 47,028.69 ounces, against 37,836.53 ounces in 1915, 35,863.89 ounces in 1914, and 29,699.38 ounces in 1913; the lead concentrates contained 21,875.79 ounces, against 20,952.08 ounces in 1915; and the zinc concentrates 126.88 ounces, against 197.06 ounces in 1915. Lead-zinc concentrate in 1916 produced 337.73 ounces of gold.

*Mine production of gold in Utah in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|
| Beaver | ..... | 176.03 | 723.06 | 666.28 | ..... | 458.25 | 2,023.62 |
| Box Elder | ..... | 39.69 | .67 | 14.21 | ..... | ..... | 54.57 |
| Emery | 5.46 | ..... | ..... | ..... | ..... | ..... | 5.46 |
| Garfield | 12.68 | 12.47 | ..... | ..... | ..... | ..... | 25.15 |
| Grand | 1.84 | ..... | .29 | ..... | ..... | ..... | 2.13 |
| Iron | ..... | 1.31 | ..... | ..... | ..... | ..... | 1.31 |
| Juab | ..... | 8,094.76 | 20,504.92 | 12,819.30 | 12.95 | ..... | 41,431.93 |
| Millard | ..... | ..... | 1.11 | ..... | ..... | ..... | 1.11 |
| Piute | ..... | 340.11 | 3.80 | 91.08 | ..... | ..... | 434.99 |
| Salt Lake | ..... | 15.27 | 92,110.85 | 13,815.21 | 381.75 | 15,247.94 | 121,571.02 |
| San Juan | 2.61 | ..... | .10 | ..... | ..... | ..... | 2.71 |
| Summit | ..... | 211.90 | ..... | 4,365.90 | ..... | 264.10 | 4,841.90 |
| Tooele | ..... | 113.48 | 24.70 | 748.26 | 26.98 | ..... | 913.42 |
| Uinta | 37.88 | ..... | ..... | ..... | ..... | ..... | 37.88 |
| Utah | ..... | 103.46 | 26.72 | 910.75 | ..... | ..... | 1,040.93 |
| Wasatch | ..... | 3.44 | ..... | 104.64 | ..... | 431.06 | 539.14 |
| Washington | ..... | 10.49 | .30 | ..... | ..... | ..... | 10.79 |
| | 60.47 | [a]9,122.41 | 113,396.52 | 33,535.63 | 421.68 | 16,401.35 | 172,938.06 |

[a] Includes 663.82 ounces from gold ore, 1,130.41 ounces from gold and silver ore, and 7,328.18 ounces from silver ore.

## SILVER.

The mine production of silver in Utah in 1916, including a small placer output, was 13,253,037 ounces, valued at $8,720,498, an increase of 939,832 ounces in quantity and of $2,477,703 in value. The largest production was from Juab County, credited with 4,892,439 ounces, against 4,005,600 ounces in 1915. Salt Lake County had the next largest output, 3,863,264 ounces in 1916, against 3,152,267 ounces in 1915. The Bingham district in Salt Lake County produced 3,095,335 ounces, or more than 80 per cent of the county total; Tintic district, in Juab and Utah counties, 5,113,566 ounces; and the Park City region, in Summit and Wasatch counties, 2,900,718 ounces. Concentrates produced at milling plants yielded 2,473,132 ounces of silver, against 2,464,903 ounces in 1915. The copper ores milled produced 488,742 ounces against 412,745 ounces in 1915, 358,486 ounces in 1914, and 324,586 ounces in 1913. Lead concentrates from low-grade lead ore contained 1,792,713 ounces of sil-

ver, or an average per ton of 10.87 ounces, against 1,887,105 ounces, or an average of 12.64 ounces, in 1915; zinc concentrates contained 4.61 ounces per ton, against 8.40 ounces per ton in 1915. The lead-zinc concentrate produced contained 17.58 ounces per ton in 1916. The silver content of bullion produced from ores treated by amalgamation was 146 ounces, against 496 ounces in 1915, and that produced by cyanidation was 194 ounces, against 5,998 ounces in 1915. The leaching process using the chloridizing roast at Park City was abandoned, and operations were finally started in the Tintic district by the Tintic Milling Co. using the Holt-Dern roasters. This company treated in the neighborhood of 30,000 tons of ore in 1916, carrying silver and copper and a little gold. The metals were contained in precipitates recovered by the use of scrap iron and shipped to the smelter. At this writing (June, 1917) several carloads of base bullion containing the metals had been shipped instead of precipitates. It is possible the company will install a refinery for the bullion.

*Mine production of silver in Utah in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Beaver | | 171 | 39,551 | 199,288 | 1,491 | ..... | 141,361 | 381,862 |
| Box Elder | | 9 | 1,520 | 4,491 | ..... | ..... | ..... | 6,020 |
| Cache | | ..... | 67 | 30 | ..... | ..... | ..... | 97 |
| Garfield | | 3 | ..... | ..... | ..... | ..... | ..... | 3 |
| Grand | | ..... | 155 | ..... | ..... | ..... | ..... | 155 |
| Iron | | 1,394 | ..... | 357 | ..... | ..... | ..... | 1,751 |
| Juab | | 847,320 | 1,091,576 | 2,948,093 | ..... | 4,097 | 1,353 | 4,892,439 |
| Millard | | ..... | 35 | 30 | ..... | ..... | ..... | 65 |
| Morgan | | ..... | 43 | 271 | ..... | ..... | ..... | 314 |
| Piute | | 1,616 | 610 | 4,962 | ..... | ..... | ..... | 7,188 |
| Salt Lake | | 605 | 1,412,538 | 1,801,186 | 650 | 101,075 | 547,210 | 3,863,264 |
| San Juan | | ..... | 269 | ..... | ..... | ..... | ..... | 269 |
| Sevier | | ..... | 16 | ..... | ..... | ..... | ..... | 16 |
| Summit | | 181,643 | ..... | 2,061,956 | 575 | ..... | 156,375 | 2,400,549 |
| Tooele | | 55,554 | 49,238 | 739,146 | 198 | 40,267 | ..... | 884,403 |
| Uinta | 2 | ..... | 26 | ..... | ..... | ..... | ..... | 28 |
| Utah | | 43,783 | 37,409 | 232,900 | ..... | ..... | ..... | 314,092 |
| Wasatch | | 21,891 | ..... | 125,554 | ..... | ..... | 352,724 | 500,169 |
| Washington | | 4 | 349 | ..... | ..... | ..... | ..... | 353 |
| | 2 | [a] 1,153,993 | 2,633,402 | 8,118,264 | 2,914 | 145,439 | 1,199,023 | 13,253,037 |

[a] Includes 1,550 ounces from gold ore, 38,159 ounces from gold and silver ore, and 1,114,284 ounces from silver ore.

## COPPER.

In 1916 the mine production of copper in Utah was 240,275,222 pounds, valued at $59,107,705, an increase of 52,604,034 pounds in quantity and of $26,265,247 in value. Bingham or West Mountain district produced 223,619,609 pounds of copper in 1916, against 176,593,414 pounds in 1915, 141,924,811 pounds in 1914, 144,920,494 pounds in 1913, 116,621,793 pounds in 1912, and 129,995,865 pounds in 1911; Tintic district produced 7,106,645 pounds in 1916, against 5,357,932 pounds in 1915; Park City region produced 1,512,578 pounds, against 2,287,172 pounds in 1915; Beaver County, 3,203,688 pounds, against 428,916 pounds in 1915; and Tooele County, 2,836,678 pounds, against 2,257,204 pounds in 1915.

Concentrates of all kinds produced at Utah milling plants contained 202,854,684 pounds of copper, against 159,593,666 pounds in

1915. Copper concentrates contained 199,997,786 pounds, against 156,436,723 pounds in 1915; lead concentrates, 2,726,091 pounds, against 3,142,093 pounds in 1915; zinc concentrates, 25,440 pounds, against 12,787 pounds in 1915; and lead-zinc concentrates, 105,367 pounds in 1916. Crude ore shipped to smelters contained 36,830,473 pounds of copper, against 27,885,899 pounds in 1915. The crude copper ores smelted contained 29,962,228 pounds, of which 21,848,946 pounds were from sulphide ores and 8,113,282 pounds were from oxidized ores. Lead ores smelted produced 5,334,126 pounds of copper, the sulphide ores yielding 3,768,915 pounds and the oxidized ores 1,565,211 pounds. Copper-lead ores, which were mostly oxidized, contained 556,622 pounds of copper. The dry or siliceous ores, used principally for fluxing at smelting plants, contained 977,497 pounds, against 686,681 pounds in 1915. Copper ore from the low-grade copper-bearing disseminated ores contained 199,996,870 pounds of copper, against 156,040,257 pounds in 1915, 125,777,441 pounds in 1914, 126,364,491 pounds in 1913, and 102,662,335 pounds in 1912. In 1916 part of the tailing of the Cactus mill, in Beaver County, was reworked and the output is included above.

*Mine production of copper in Utah in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|
| Beaver | ..... | 2,914,622 | 167,132 | ..... | 121,934 | 3,203,688 |
| Box Elder | ..... | 981,526 | 304 | ..... | ..... | 981,830 |
| Cache | ..... | 5,740 | ..... | ..... | ..... | 5,740 |
| Grand | ..... | 2,918 | ..... | ..... | ..... | 2,918 |
| Juab | 1,406,729 | 5,357,291 | 355,370 | 5,360 | ..... | 7,124,750 |
| Millard | ..... | 3,834 | ..... | ..... | ..... | 3,834 |
| Morgan | ..... | 1,031 | ..... | ..... | ..... | 1,031 |
| Piute | 235 | 4,422 | 965 | ..... | ..... | 5,622 |
| Salt Lake | 3,686 | 220,097,157 | 3,274,198 | 404,972 | 688,743 | 224,468,756 |
| San Juan | ..... | 34,971 | ..... | ..... | ..... | 34,971 |
| Sevier | ..... | 3,056 | ..... | ..... | ..... | 3,056 |
| Summit | 4,058 | ..... | 1,091,031 | ..... | 68,552 | 1,163,641 |
| Tooele | 1,929 | 484,319 | 2,200 808 | 149,622 | ..... | 2,836,678 |
| Uinta | ..... | 5,423 | ..... | ..... | ..... | 5,423 |
| Utah | 2,640 | 31,487 | 18,003 | ..... | ..... | 52,130 |
| Wasatch | 7,640 | ..... | 105,032 | ..... | 236,265 | 348,937 |
| Washington | ..... | 32,217 | ..... | ..... | ..... | 32,217 |
| | [a] 1,426,917 | 229,960,014 | 7,212,843 | 559,954 | 1,115,494 | 240,275,222 |

[a] Includes 2,529 pounds from gold ore, 13,820 pounds from gold and silver ore, and 1,410,568 pounds from silver ore.

## LEAD.

The mine production of lead in Utah in 1916 was 201,490,075 pounds, exceeding the output of any previous year, and was 1,522,638 pounds more than the output in 1915. Bingham or West Mountain district, with 85,996,490 pounds, had the largest production in 1916, against 80,004,006 pounds in 1915, 76,453,128 pounds in 1914, 71,001,138 pounds in 1913, and 43,822,495 pounds in 1912. The greatest part of the production at Bingham came from the Utah Apex, the Highland Boy, the Utah Metal & Tunnel Co. properties, and the Bingham-New Haven, Brooklyn, Dalton & Lark, and Yosemite mines. The Park City region produced 33,233,794 pounds of lead, against 49,350,377 pounds in 1915. The Tintic district produced 39,294,351 pounds, against 32,657,018 pounds in 1915. The combined

production of the Ophir and Rush Valley districts, in Tooele County, aggregated 18,275,389 pounds, against 16,383,700 pounds in 1915. The output in Beaver County decreased from 8,589,416 pounds in 1915 to 5,948,220 pounds in 1916. Lead contained in concentrate recovered at milling plants and shipped to smelters amounted to 61,315,355 pounds, against 62,868,183 pounds in 1915. The lead concentrates averaged 18.18 per cent of lead in 1916, against 20.77 per cent in 1915; zinc concentrates contained 390,460 pounds, averaging 1.05 per cent of lead in 1916, against 2.19 per cent in 1915. The total crude ore of shipping grade contained 138,628,633 pounds, against 135,391,781 pounds in 1915. Sulphide lead ore contained 67,837,865 pounds of lead, against 64,717,208 pounds in 1915. The oxidized lead ores carried 67,067,162 pounds, against 68,462,869 pounds in 1915. Of the zinc ores shipped in 1916, the oxidized ores contained 229,196 pounds of lead and the sulphide ores 1,681 pounds. Of the copper-lead ores, the oxidized or carbonate ores contained 1,659,362 pounds and the sulphide ores 26,699 pounds of lead.

*Mine production of lead in Utah in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|
| Beaver | ..... | ..... | 4,046,435 | 35,000 | ..... | 1,866,785 | 5,948,220 |
| Box Elder | ..... | ..... | 888,413 | 155,698 | ..... | 174,208 | 1,218,319 |
| Cache | ..... | ..... | 8,950 | 64 | ..... | ..... | 9,014 |
| Iron | ..... | ..... | 134,537 | ..... | ..... | ..... | 134,537 |
| Juab | 140,575 | 1,782 | 36,277,170 | 12,195 | 17,770 | 114,215 | 36,563,707 |
| Millard | ..... | ..... | 7,901 | ..... | ..... | ..... | 7,901 |
| Morgan | ..... | ..... | 36,843 | ..... | ..... | ..... | 36,843 |
| Piute | ..... | ..... | 49,983 | ..... | ..... | ..... | 49,983 |
| Salt Lake | 1,465 | 4,662 | 71,338,257 | 3,912 | 990,414 | 29,089,602 | 101,428,312 |
| Sevier | ..... | 96 | ..... | ..... | ..... | ..... | 96 |
| Summit | 53,836 | ..... | 22,731,861 | 1,681 | ..... | 2,284,975 | 25,072,353 |
| Tooele | 6,820 | ..... | 18,017,013 | ..... | 688,092 | 15,746 | 18,727,671 |
| Utah | ..... | ..... | 4,109,351 | 22,327 | ..... | ..... | 4,131,678 |
| Wasatch | 43,332 | ..... | 1,614,117 | ..... | ..... | 6,503,992 | 8,161,441 |
| | [a]246,028 | 6,540 | 159,260,831 | 230,877 | 1,696,276 | 40,049,523 | 201,490,075 |

[a] Includes 94,635 pounds from gold and silver ore and 151,393 pounds from silver ore.

## ZINC.

The new district of Promontory in Box Elder County continued to produce in 1916, the output of zinc being slightly in excess of that of 1915. Tintic, North Tintic, Park City, Ophir, Stockton, Bingham districts, and Beaver County were important producers. The total mine production of recoverable zinc in Utah in 1916 was 29,572,528 pounds, valued at $3,962,719, against 24,292,240 pounds, valued at $3,012,238, in 1915. The mines of the Park City region yielded 5,136,353 pounds of recoverable zinc, compared with 7,771,350 pounds in 1915. Most of the production was from the Daly Judge property, and a considerable quantity was derived from the old tailings on the flats below the town. Salt Lake County, with Bingham the principal source, produced 11,376,384 pounds of recoverable zinc, against 5,721,022 pounds in 1915. Beaver County increased in output from 2,989,811 pounds in 1915 to 3,969,405 pounds in 1916. The Promontory district of Box Elder County yielded 2,668,401 pounds

of zinc in 1916, against 2,482,578 pounds in 1915. Tintic district decreased in output from 3,845,058 pounds in 1915 to 3,711,156 pounds in 1916.

Lead-zinc ores, of which 269,335 tons were concentrated, produced 18,433 tons of zinc concentrate containing 14,020,354 pounds of zinc, against 14,369,838 pounds in 1915. In addition to this output of mill product, 183,026 tons (estimated) of old tailing produced 6,042 tons of lead-zinc concentrate, yielding 3,719,160 pounds of recoverable zinc. Crude zinc ores and lead-zinc ores smelted contained 11,435,359 pounds of zinc, of which 8,467,927 pounds were derived from zinc ores and 2,967,432 pounds from lead-zinc ores. In 1916 the oxidized zinc and lead-zinc ores predominated and produced, respectively, 8,455,489 pounds and 1,180,868 pounds of recoverable zinc. The sulphide zinc ores yielded 12,438 pounds and the sulphide lead-zinc ores 1,786,564 pounds of recoverable zinc.

*Mine production of recovered zinc in Utah in 1916, in dry pounds.*

| County. | Zinc ore | Lead-zinc ore. | Total. |
|---|---|---|---|
| Beaver | 209,605 | 3,759,800 | 3,969,405 |
| Box Elder | 2,015,543 | 652,858 | 2,668,401 |
| Cache | 988 | | 988 |
| Juab | 2,359,210 | 218,229 | 2,577,439 |
| Salt Lake | 435,901 | 10,940,483 | 11,376,384 |
| Summit | 12,438 | 2,904,143 | 2,916,581 |
| Tooele | 2,507,511 | 11,661 | 2,519,172 |
| Utah | 1,324,386 | | 1,324,386 |
| Wasatch | | 2,219,772 | 2,219,772 |
| | 8,865,582 | 20,706,946 | 29,572,528 |

*Zinc ore and concentrates produced from Utah mines and mills sold in 1916.*

| Classification. | County. | Quantity. | Average assay of ore or concentrates.[a] |
|---|---|---|---|
| | | *Short tons (dry weight).* | *Per cent of zinc.* |
| Sulphide ore | Beaver, Salt Lake, Summit, and Tooele | [b] 8,563 | 15.83 |
| Mixed carbonate and siliceous ore | Beaver, Box Elder, Cache, Juab, Salt Lake, Tooele, and Utah. | 19,342 | 29.31 |
| Concentrates | Beaver, Salt Lake, Summit, and Wasatch. | 18,703 | 46.35 |
| | | 46,608 | 33.67 |

[a] Actual zinc content.
[b] Represents ore, part of which was treated at an electrolytic plant in Utah and some contained both lead and zinc shipped to an oxide plant situated in the east.

## METAL-MINING INDUSTRY IN UTAH IN 1916.

All metal-producing properties in Utah were operated at fullest capacity in 1916, sharing the unusual prosperity of the industry. Part of the time the smelters were congested with the ore offered for reduction, not only from Utah mines but also from mines in Nevada, Idaho, Montana, California, and Colorado. The production of metals was much larger than that of 1915, as there was little or no trouble with labor. Extensions of electric-power lines were made

in several camps, notably to properties in the American Fork district. Work was continued on the transportation and drainage adits opening up the Daly-Judge mines from Snake Creek and on the Alta Tunnel to drain properties in Alta at depth into the Big Cottonwood Creek. The new 5,000-foot drainage adit of the Wasatch mines was started in Little Cottonwood Canyon, a short distance from Alta, to unwater the old Columbus Consolidated stopes, which had ore exposures at water level. No important mineral discoveries were made.

Construction was started on a new railroad into the Deep Creek region, covering Tooele County and part of Juab County. This road will connect with the Western Pacific Railroad at Wendover, 43 miles from Gold Hill, the proposed terminus. The Alta narrow-gage railway was completed a good part of the distance between Wasatch and Alta. Financial difficulties and trouble in getting material delayed work on the road.

## METALLURGIC INDUSTRY.

### GENERAL STATEMENT.

Several new milling plants were erected and additions were made to old ones. Gold and silver bullion recovered by amalgamation and cyanidation was negligible. Cyanidation and concentration was attempted on the silver ores of the Ophir mine in Iron County, and operations on a small scale were started at the Daisy property in the West Dip section of the Camp Floyd district. In the Newton district of Beaver County lessees milled some ore from the Golconda properties by amalgamation. There was also a small lot of amalgamated ore reported from the Oro property situated in the Imperial district of Garfield County.

*Gold and silver produced in mills in Utah in 1916.*

| County. | Ore. | Bullion recovered from ore by— | | | | Total value. |
|---|---|---|---|---|---|---|
| | | Amalgamation. | | Cyanidation. | | |
| | | Gold. | Silver. | Gold. | Silver. | |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | |
| Beaver, Box Elder, Garfield, Iron, Tooele, and Washington | [a] 1,423 | 234.64 | 146 | 74.43 | 194 | $6,613 |

[a] Also yielded 1 ton of concentrate.

Quicksilver amounting to 15 pounds was reported to have been consumed in 1916 at milling plants, and 1,200 pounds of sodium and potassium cyanide were used.

## MINE PRODUCTION.

*Mine production of metals from Utah concentrates in 1916.*

**By counties.**

| County. | Ore to concentrating mills. | Concentrates produced. | | | | | | Total value of concentrates. |
|---|---|---|---|---|---|---|---|---|
| | | Quantity. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | |
| | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Beaver | 4,281 | 12,581 | 714.18 | 149,396 | 1,559,380 | 1,757,761 | 3,418,970 | $1,076,102 |
| Iron | | 1 | .29 | 478 | | | | 321 |
| Juab | 2,282 | 174 | 20.88 | 4,550 | 680 | 137,400 | | 13,074 |
| Salt Lake | 12,034,343 | 677,578 | 66,816.88 | 1,271,958 | 199,850,974 | 38,599,583 | 9,196,629 | 55,277,234 |
| Summit | 61,868 | 18,248 | 1,120.61 | 375,737 | 161,648 | 6,654,036 | 2,904,143 | 1,158,448 |
| Tooele | 62,400 | 27,642 | 249.76 | 315,669 | 1,045,217 | 7,583,983 | | 993,291 |
| Utah | 1,965 | 131 | 15.72 | 2,620 | 520 | 78,600 | | 7,600 |
| Wasatch | 61,787 | 12,948 | 431.06 | 352,724 | 236,265 | 6,503,992 | 2,219,772 | 1,045,349 |
| | 12,228,926 | 749,303 | 69,369.38 | 2,473,132 | 202,854,684 | 61,315,355 | 17,739,514 | 59,571,419 |

**By kinds of concentrates.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Siliceous | 1 | .29 | 478 | | | | 321 |
| Copper | 559,840 | 47,028.69 | 488,742 | 199,997,786 | | | 50,493,216 |
| Lead | 164,987 | 21,875.79 | 1,792,713 | 2,726,091 | 60,007,367 | | 6,442,945 |
| Zinc | 18,433 | 126.88 | 84,955 | 25,440 | 390,460 | 14,020,354 | 1,970,450 |
| Lead-zinc | 6,042 | 337.73 | 106,244 | 105,367 | 917,528 | 3,719,160 | 664,487 |

Of the 26 milling plants operated in 1916 in Utah, 4 were amalgamating plants, 2 used cyanidation only, and 16 were solely concentration plants, of which 10 were equipped for the oil-flotation process and 2 used the process entirely. There were 2 leaching plants, of which one used sulphuric acid processes and the other chlorination roasting. The chlorination roasting plant at Silver City received silver ore containing a little copper and gold from 14 properties in the Tintic district and shipped several carloads of precipitates containing the metals recovered from solution on scrap iron. The process is said to be a success, and the operators are beginning to add several improvements toward making base bullion and planning for its refinement.

*Mine production of metals from Utah crude ore shipped to smelters in 1916.*

**By counties.**

| County. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Beaver | 44,625 | 1,130.09 | 222,853 | 1,641,039 | 3,820,628 | 550,435 | $911,075 |
| Box Elder | 14,907 | 14.88 | 6,011 | 981,830 | 1,218,319 | 2,668,401 | 687,421 |
| Cache | 81 | ..... | 97 | 5,740 | 9,014 | 988 | 2,230 |
| Grand | 15 | .29 | 155 | 2,918 | ..... | ..... | 826 |
| Iron | 261 | .56 | 1,079 | ..... | 134,537 | ..... | 10,005 |
| Juab | 322,549 | 40,564.35 | 4,695,354 | 6,677,290 | 36,426,307 | 2,577,439 | 8,429,487 |
| Millard | 40 | 1.11 | 65 | 3,834 | 7,901 | ..... | 1,554 |
| Morgan | 100 | ..... | 314 | 1,031 | 36,843 | ..... | 3,003 |
| Piute | 326 | 434.99 | 7,188 | 5,022 | 49,983 | ..... | 18,554 |
| Salt Lake | 781,715 | 54,696.52 | 2,582,190 | 24,576,096 | 62,481,539 | 1,788,207 | 13,426,324 |
| San Juan | 68 | .10 | 269 | 34,971 | ..... | ..... | 8,782 |
| Sevier | 9 | ..... | 16 | 3,056 | 96 | ..... | 769 |
| Summit | 45,310 | 3,702.41 | 2,020,925 | 990,856 | 18,175,469 | 12,438 | 2,905,829 |
| Tooele | 51,780 | 497.26 | 554,557 | 1,706,008 | 10,557,470 | 2,513,065 | 1,860,294 |
| Uinta | 5 | ..... | 26 | 5,423 | ..... | ..... | 1,351 |
| Utah | 14,670 | 999.51 | 297,165 | 48,970 | 4,053,078 | 1,324,386 | 685,374 |
| Wasatch | 4,966 | 108.08 | 147,445 | 112,672 | 1,657,449 | ..... | 241,334 |
| Washington | 149 | .31 | 349 | 32,217 | ..... | ..... | 8,161 |
| | 1,281,576 | 102,150.43 | 10,536,058 | 36,830,473 | 138,628,633 | 11,435,359 | 29,202,373 |

**By kinds of ore.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dry or siliceous | 58,514 | 7,940.66 | 946,333 | 977,497 | 246,028 | ..... | $1,044,274 |
| Copper | 732,680 | 66,367.81 | 2,144,660 | 29,962,228 | 6,540 | ..... | 10,154,290 |
| Lead | 454,396 | 27,424.38 | 7,295,424 | 5,334,126 | 134,905,027 | ..... | 15,987,943 |
| Zinc | 16,889 | ..... | 2,914 | ..... | 230,877 | 8,467,927 | 1,152,550 |
| Copper-lead | 9,592 | 416.38 | 144,753 | 556,622 | 1,686,061 | ..... | 357,122 |
| Lead-zinc | 9,505 | 1.23 | 1,974 | ..... | 1,554,100 | 2,967,432 | 506,194 |

The American Smelting & Refining Co.'s lead smelter at Murray operated 6 furnaces on lead ores in 1916. At this plant electrolytic zinc was also produced at the rate of about 2 tons a day from an experimental plant. This was closed later in the year on account, it is said, of the high cost of electric power. A sulphuric-acid plant was added to the copper smelting plant at Garfield. Two of the Herreshoff roasters were connected with the acid chambers, providing gas sufficient to manufacture about 100 tons of acid daily. It is expected that the capacity will be increased to 150 tons a day. It was built primarily to furnish acid for the new leaching plant of the Utah Copper Co., now in course of construction. At this writing (June, 1917) the entire supply of the plant is sold to various metallurgical concerns in the West. It is expected the Utah Copper leaching plant will be ready for operation late in 1917. The Garfield copper smelter operated 4 blast furnaces and 5 out of 6 reverberatories on copper ores. To this plant were added 2 more converters as well as 10 new Herreshoff roasters. About 3,500 tons of ore and concentrates per day were treated. The International smelter at Tooele had 5 lead furnaces in blast operating its lead plant at capacity. Four out of 5 copper reverberatory furnaces were in operation. The lead plant has been handling an average of 1,400 tons of ore a day and the copper plant about 1,500 tons. The United States (Midvale) smelter ran 5 furnaces on lead ore. Metallic cadmium was recovered by the electrolytic process from fumes from the bag house. Arsenic

as well as thalium were also produced as by-products. From the annual report[1] of the company the following paragraphs are taken:

The most noteworthy improvements in the smelting plant at Midvale, Utah, were the installations of a seventh furnace, a magnetic separator, and a thaw house. The receipt of ore was so large that the increase in the smelting capacity was found necessary in order to prevent an undue accumulation purchased under high metal quotations. The magnetic separator is successfully recovering the values from pyrites which heretofore have been unprofitable. The thaw house has improved not only the conditions for unloading frozen ore from cars, but incidentally is aiding the mill to treat a larger tonnage than would be possible without it.

There is now in process of erection a Weatherby electric separator for the purpose of further improving recoveries. Completion has been retarded by slow deliveries of material.

Experiments are being made for the installation of a flotation plant to treat the tailings from the mill.

At the concentration mills of the Utah Copper Co. some changes were made to improve recoveries and increase the ore capacity of the plants. When these improvements, which consist principally in adding to fine grinding and concentrating equipment, are completed it is estimated the two plants will have a capacity of approximately 40,000 tons of ore a day, accompanied by maximum metallurgical efficiency. Construction work was commenced in August on the new leaching plant for the daily treatment of between 3,000 and 4,000 tons of oxidized copper ores. This plant should be complete in the summer of 1917. The material to be treated is the oxidized and partly oxidized "capping" overlying the sulphide ore bodies.

In order to furnish acid for the leaching plant and mills, as well as to supply some other local and commercial requirements, the Utah Copper Co. participated equally with the Garfield Smelting Co. in the construction and operation of an acid plant near the smelter. In December the plant was complete and produced some sulphuric acid. The plant will produce 75 tons a day, and with construction of additional units will have a capacity of 150 tons before the end of 1917.

## PRODUCTION BY COUNTIES.

### GENERAL FEATURES.

A table follows showing the total output of the State by counties in 1916 and the mine production of each metal with its total value; a second table shows production of ore and average value per ton by counties in 1915 and 1916; and a review describes the mining industry in each county and each producing mining district.

[1] United States Smelting, Refining & Mining Co. Eleventh Ann. Rept., for year ending Dec. 31, 1916.

*Mine production of gold, silver, copper, lead, and zinc in Utah in 1916.*

| County. | Gold. | | | | | Silver. | |
|---|---|---|---|---|---|---|---|
| | Placers. | | Deep mines. | | Total value. | Quantity. | Value. |
| | Quantity. | Value. | Quantity. | Value. | | | |
| | *Fine ounces.* | | *Fine ounces.* | | | *Fine ounces* | |
| Beaver | | | 2,023.62 | $41,832 | $41,832 | 381,862 | $251,265 |
| Box Elder | | | 54.57 | 1,128 | 1,128 | 6,020 | 3,961 |
| Cache | | | | | | 97 | 64 |
| Emery | 5.46 | 113 | | | 113 | | |
| Garfield | 12.68 | 262 | 12.47 | 258 | 520 | 3 | 2 |
| Grand | 1.84 | 38 | .29 | 6 | 44 | 155 | 102 |
| Iron | | | 1.31 | 27 | 27 | 1,751 | 1,152 |
| Juab | | | 41,431.93 | 856,474 | 856,474 | 4,892,439 | 3,219,225 |
| Millard | | | 1.11 | 23 | 23 | 65 | 43 |
| Morgan | | | | | | 314 | 207 |
| Piute | | | 434.99 | 8,992 | 8,992 | 7,188 | 4,730 |
| Salt Lake | | | 121,571.02 | 2,513,096 | 2,513,096 | 3,863,264 | 2,542,028 |
| San Juan | 2.61 | 54 | .10 | 2 | 56 | 269 | 177 |
| Sevier | | | | | | 16 | 10 |
| Summit | | | 4,841.90 | 100,091 | 100,091 | 2,400,549 | 1,579,561 |
| Tooele | | | 913.42 | 18,882 | 18,882 | 884,403 | 581,937 |
| Uinta | 37.88 | 783 | | | 783 | 28 | 18 |
| Utah | | | 1,040.93 | 21,518 | 21,518 | 314,092 | 206,673 |
| Wasatch | | | 539.14 | 11,145 | 11,145 | 500,169 | 329,111 |
| Washington | | | 10.79 | 223 | 223 | 353 | 232 |
| | 60.47 | 1,250 | 172,877.59 | 3,573,697 | 3,574,947 | 13,253,037 | 8,720,498 |

| County. | Copper. | | Lead. | | Recoverable zinc. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Beaver | 3,203,688 | $788,107 | 5,948,220 | $410,427 | 3,969,405 | $531,900 | $2,023,531 |
| Box Elder | 981,830 | 241,530 | 1,218,319 | 84,064 | 2,668,401 | 357,565 | 688,248 |
| Cache | 5,740 | 1,412 | 9,014 | 622 | 988 | 132 | 2,230 |
| Emery | | | | | | | 113 |
| Garfield | | | | | | | 522 |
| Grand | 2,918 | 718 | | | | | 864 |
| Iron | | | 134,537 | 9,283 | | | 10,462 |
| Juab | 7,124,750 | 1,752,689 | 36,563,707 | 2,522,896 | 2,577,439 | 345,377 | 8,606,661 |
| Millard | 3,834 | 943 | 7,901 | 545 | | | 1,554 |
| Morgan | 1,031 | 254 | 36,843 | 2,542 | | | 3,003 |
| Piute | 5,622 | 1,383 | 49,983 | 3,449 | | | 18,554 |
| Salt Lake | 224,468,756 | 55,219,314 | 101,428,312 | 6,998,554 | 11,376,384 | 1,524,436 | 68,797,428 |
| San Juan | 34,971 | 8,603 | | | | | 8,836 |
| Sevier | 3,056 | 752 | 96 | 7 | | | 769 |
| Summit | 1,163,641 | 286,256 | 25,072,353 | 1,729,992 | 2,916,581 | 390,822 | 4,086,722 |
| Tooele | 2,836,678 | 697,823 | 18,727,671 | 1,292,209 | 2,519,172 | 337,569 | 2,928,420 |
| Uinta | 5,423 | 1,334 | | | | | 2,135 |
| Utah | 52,130 | 12,824 | 4,131,678 | 285,086 | 1,324,386 | 177,468 | 707,569 |
| Wasatch | 348,937 | 85,838 | 8,161,441 | 563,139 | 2,219,772 | 297,450 | 1,286,683 |
| Washington | 32,217 | 7,925 | | | | | 8,380 |
| | 240,275,222 | 59,107,705 | 201,490,075 | 13,902,815 | 29,572,528 | 3,962,719 | 89,268,684 |

*Ore sold or treated, number of deep mines producing, and value of ores in Utah in 1915 and 1916.*

| County. | Ore sold or treated. | | Number of deep mines producing. | | Average total value per ton.[a] | | Average value per ton in gold and silver.[a] | |
|---|---|---|---|---|---|---|---|---|
| | 1916 | Increase or decrease. | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 |
| | *Short tons.* | *Short tons.* | | | | | | |
| Beaver | 276,141 | + 222,327 | 23 | 49 | $18.66 | $7.33 | $2.88 | $1.06 |
| Box Elder | 15,207 | + 8,193 | 3 | 6 | 52.35 | 45.26 | ..... | .33 |
| Cache | 81 | + 40 | 2 | 3 | 51.51 | 27.53 | ..... | .79 |
| Emery | ..... | — 149 | 1 | ..... | 49.86 | ..... | .42 | ..... |
| Garfield | 30 | + 29 | 1 | 1 | 137.00 | 8.66 | 6.00 | 8.66 |
| Grand | 15 | + 13 | 1 | 2 | 55.00 | 55.07 | 17.50 | 7.20 |
| Iron | 611 | — 256 | 2 | 3 | 7.11 | 17.12 | 7.11 | 1.93 |
| Juab | 352,781 | + 67,998 | 43 | 58 | 19.51 | 24.65 | 10.33 | 11.55 |
| Millard | 40 | + 1 | 1 | 2 | 28.95 | 38.85 | 24.61 | 1.65 |
| Morgan | 100 | — 8 | 1 | 2 | 23.47 | 30.03 | 1.99 | 2.07 |
| Piute | 326 | + 134 | 4 | 7 | 183.49 | 56.91 | 181.48 | 42.09 |
| Salt Lake | 12,831,661 | +3,113,659 | 67 | 81 | 4.13 | 5.36 | .42 | .39 |
| San Juan | 68 | + 68 | ..... | 1 | ..... | 129.14 | ..... | 2.63 |
| Sevier | 9 | + 9 | ..... | 1 | ..... | 85.44 | ..... | 1.11 |
| Summit | 233,845 | + 40,291 | 15 | 17 | 20.99 | 17.47 | 8.52 | 7.18 |
| Tooele | 124,695 | + 12,804 | 37 | 48 | 15.29 | 23.48 | 3.45 | 4.82 |
| Uinta | 5 | — 1 | 1 | 1 | 169.33 | 270.20 | 2.33 | 3.66 |
| Utah | 18,111 | + 7,177 | 18 | 18 | 54.01 | 38.85 | 18.99 | 12.60 |
| Wasatch | 66,753 | — 3,035 | 4 | 3 | 23.07 | 19.27 | 4.89 | 5.10 |
| Washington | 164 | — 74 | 4 | 7 | 79.44 | 51.09 | 53.29 | 2.77 |
| Weber | ..... | — 22 | 1 | ..... | 15.95 | ..... | .50 | ..... |
| | 13,920,643 | +3,469,198 | 229 | 310 | 5.27 | 6.41 | .94 | .88 |

[a] Placer product excluded.

## BEAVER COUNTY.

*Mine production in Beaver County, Utah, 1915–16.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 23 | 53,814 | $13,028 | 279,694 | 428,916 | 8,589,416 | 2,989,811 | $1,004,333 |
| 1916 | 49 | 276,141 | 41,832 | 381,862 | 3,203,688 | 5,948,220 | 3,969,405 | 2,023,531 |
| Increase or decrease, 1916 | ..... | +222,327 | +28,804 | +102,168 | +2,774,772 | −2,641,196 | +979,594 | +1,019,198 |
| Total, 1860–1916 | ..... | ..... | 722,425 | 20,863,073 | 45,936,298 | 406,082,554 | 29,374,055 | 47,211,876 |

The county has a record since 1860 of gold, silver, copper, lead, and zinc amounting in total value to $47,211,876. This includes $722,425 in gold, $19,342,977 in silver, $7,467,924 in copper, $17,523,134 in lead, and $2,155,416 in zinc. The corresponding table of production by years is given to the end of the year 1913 in Mineral Resources for 1913, Part I, page 389.

Forty-nine mines in 1916 produced 276,141 tons of ore, against 23 mines and 53,814 tons of ore in 1915. The total value of the output of gold, silver, copper, lead, and zinc increased from $1,004,333 in 1915 to $2,023,531 in 1916. The production of all the metals, with the exception of lead, increased in quantity, and the value of all metals increased. The value of the gold increased from $13,028 in 1915 to $41,832 in 1916; silver, from $141,805 to $251,265; copper,

from $75,060 to $788,107; lead, from $403,703 to $410,427; and zinc, from $370,737 to $531,900. The average value per ton of the ore, including some old slag, decreased from $18.66 in 1915 to $7.33 in 1916, and the gold and silver value per ton in this ore from $2.88 to $1.06. The decrease in the value per ton was caused by the treatment of considerable low-grade tailing in addition to the slag shipped. Of the ore mined, 4,281 tons were concentrated, and produced lead, zinc, and lead-zinc concentrates carrying values in gold, silver, and copper. There was also an output of copper concentrate which came from the re-treatment of old tailings at Newhouse from the Cactus mine. Altogether there were 12,581 tons of concentrates having a total value of $1,076,102, or $85.53 per ton. Crude ore shipped, mostly oxidized, aggregated 44,625 tons, which yielded at the smelters gold, silver, copper, lead, and zinc, having a total value of $911,075, or an average value per ton of $20.42.

*Beaver Lake district.*—There was considerable activity in this district during 1916, and several properties were prepared for large production. Six producers shipped 730 tons of oxidized copper and lead ores, the total content of which was 10.89 ounces of gold, 724 ounces of silver, 81,088 pounds of copper, and 33,394 pounds of lead, valued in all at $22,953, or an average per ton of $31.44. The largest output came from the O. K. property, operated by the Majestic Mines Co., and the Milford-Utah property. The Beaver Lake, Beaver Metals, and Copper Mountain claims also produced small quantities of ore.

*Bradshaw district.*—Small quantities of lead ore, mostly oxidized, were produced by lessees from the Summit and Cave properties.

*Granite district.*—Lessees shipped from the King of the Hills property a small tonnage of oxidized copper ore. Three other producers shipped small quantities of ore.

*Lincoln district.*—The largest producer was the Creole property. The ore was copper oxidized and was mined by lessees. The Rattler, Croff, and Stampede properties also produced ore. Altogether there were 4,818 tons of ore shipped in 1916, having a total value for gold, silver, copper, and lead of $92,658, or an average value per ton of $19.23.

*Newton district.*—An active development of mines in 1916 was not successful in disclosing very large quantities of ore. Therefore, several of the properties were abandoned by those who had them under option. Only a small quantity of gold and silver ore was shipped by lessees from two properties. The output of 359 tons of ore was valued at $3,752, or an average value per ton of $10.45.

*North Granite district.*—About four carloads of oxidized copper ore, carrying very low values in copper, was shipped from the Mammoth Copper property. A small quantity of lead ore was shipped from a prospect in the district.

*Preuss district.*—Lead ore was shipped from the Hendrickson mine and also from the Indian Queen and the Galena properties in 1916.

*Rocky district.*—Oxidized copper ore was shipped from the Montreal property. This ore carries about 10 per cent of silica and 35 per cent of iron. The ore deposit occurs at the contact of the limestone and monzonite. It is opened by an adit 600 feet long. The Copper Ranch property, opened by an incline shaft about 400 feet deep, was also a shipper of copper ore. From the Old Hickory property some

low-grade copper ore carrying silver values was produced. Altogether the district produced 20,797 tons of ore, containing 29.16 ounces of gold, 8,153 ounces of silver, 935,697 pounds of copper, valued in all at $236,149, or an average value per ton of $11.36.

*San Francisco district.*—Nine producers reported the output and treatment of 240,876 tons of ore, old tailings, and slag, containing $26,067 in gold, 302,555 ounces of silver, 1,722,138 pounds of copper, 4,057,261 pounds of lead, and 3,450,671 pounds of recoverable zinc, valued in all at $1,391,135. Included in this were 10,013 tons of ore shipped directly to the smelters. From the old tailings and some crude ore of milling grade treated 12,425 tons of concentrate were shipped. In 1915 the metal production from 46,076 tons of ore and old slag was valued at $773,462. The largest producer of ore was the Horn Silver mine, yielding mixed lead sulphide and carbonate and zinc sulphide ore. The company continued to ship some of its milling ore, yielding lead and zinc concentrates, to the Midvale concentrator. The old tailing dump at the mine, under lease to the Caldo Leasing Co., produced a fine grade of lead and zinc concentrates, carrying good values in silver recovered by flotation concentration. At the Horn Silver mine two small ore bodies were developed in 1916 at points deeper than any heretofore found. According to the annual report of the company the property[1] in 1916 yielded 8,504 tons of mixed carbonate and sulphide ore containing lead and silver, 102 tons of zinc ore, 3,986 tons of zinc-lead ore, 1,237 tons of copper ore, and 2,739 tons of slag from the old smelter dumps. Workings on the 1,000 and 1,100 foot levels were reopened and retimbered and the main shaft was completed to a depth of 1,150 feet.

At Newhouse the Cactus tailings were worked in the oil flotation mill of the Utah Leasing Co., which reports making a high saving and a good margin of profit, which will continue as long as the price of copper remains above 15 cents a pound. Lessees operating on the Imperial property shipped two carloads of copper ore.

*Star districts (North and South).*—The output of these districts was almost double that of 1915. Nine producers reported the output of 7,823 tons of ore, containing $2,560 in gold, 49,188 ounces of silver, 153,696 pounds of copper, 1,717,284 pounds of lead, and 467,734 pounds of zinc, valued in all at $253,903, or an average value per ton of $32.46. The largest output was from the Moscow mine, consisting of lead ores containing silver and a little copper. A small quantity of zinc ore was also shipped. The main working shaft is 1,100 feet deep. At the Harrington-Hickory & Hoosier Boy property work was continued throughout the year and lead ore and lead-zinc ore were produced. Among the remaining producers were the Cedar-Talisman, Monitor, and Empire properties. A test lot of copper ore was shipped from the Commonwealth mine.

*Washington district.*—Although there was considerable activity in prospecting and opening some of the surface deposits of copper ore, very little ore was shipped from the district in 1916.

### BOX ELDER COUNTY.

*Lucin district.*—The Salt Lake Copper Co., through its lessees, shipped copper and lead ores mined from the surface and from the old

[1] Horn Silver Mining Co. Ann. Rept. for year ending Dec. 31, 1916.

workings of the property. There was a small quantity of lead ore reported from two other properties in the district. The Tecoma property, an old lead-silver producer, is said to have yielded all of its ore from within 60 feet of the surface. Lessees started work on the mine and will probably make a considerable output in 1917.

*Newfoundland district.*—From the mine dump of the Mineral Monarch property a small shipment of oxidized copper ore was made to the smelter near Salt Lake.

*Park Valley district.*—The mine dump of the Golconda property was sluiced and free gold was caught on amalgamating plates; a shipment of a small quantity of bullion resulted.

*Promontory district.*—Reports from the district show that a smaller production of zinc and lead ore was made in the last half of 1916 than at any time since the discovery of the deposits. Prospecting in an effort to open new deposits has been carried on with very little success.

The Lake View property was the principal producer of oxidized zinc ore and a little lead ore. At this property the leasing system was adopted the latter part of 1916. The dividends paid stockholders since the beginning of operations total $124,000, of which $65,000 was paid in 1916.

### CACHE COUNTY.

In the vicinity of Paradise, the Wolf Mountain and Lucky Star properties were operated, each producing ore which was shipped to the smelters near Salt Lake City. The Lucky Star claim is in Blacksmith Fork Canyon, and the ore shipped contained some lead and zinc and a little silver. The opening of the deposits on the Wolf Mountain property created some interest, as the ore mined and shipped carried high values in copper with little silver.

*Richmond district.*—Prospecting and development during 1916 yielded only one small lot of lead ore, which was shipped from the Kimberly claims.

### GARFIELD COUNTY.

In the Imperial or Henry Mountain region, near Hanksville, the Oro property produced a little gold ore, which was treated in a small amalgamation mill. There was some prospecting in the vicinity of the Bromide mine, but no output was reported.

### IRON COUNTY.

*Calumet district.*—An old property, formerly known as the Arrowhead claim, was reopened under the name of the Calumet, and 238 tons of oxidized lead ore, carrying very small values in silver, was shipped to the smelting plant near Salt Lake City during the year. The property is opened by two vertical shafts, the deepest of which is 75 feet. The ore deposit, 2 by 3 feet thick in places, follows the bedded limestone, which has a general strike said to be N. 40° W. and dips about 20° NE. from the horizontal.

*Stateline district.*—Work continued at the Ophir mine by lessees, and some concentrating and cyaniding silver ores were mined from the property. The mill was operated about six weeks. The work

of getting the mine and mill in shape for operation covered a period of about eight months, after which the operations were stopped pending the installation of a more economical process.

## JUAB COUNTY.

Fifty-eight producers made an output in 1916 of 352,781 tons of ore, containing gold, silver, copper, lead, and zinc, valued at $8,696,661, an increase of 67,998 tons in quantity and of $3,141,183 in value, as compared with the output of 43 producers in 1915 of 284,783 tons, valued at $5,555,478. The output was principally from the Tintic district.

*Deseret Mountain district.*—The ores mined from this district carry good values in copper and are largely sulphides. The Deseret Mountain property has the largest amount of development work, and is opened by two incline shafts 127 feet deep and by 600 feet of drifts. One car of lead ore was shipped from the Lucky Shepherd prospect. The output of the district in 1917 promises to be of importance. Nearly all the ore is shipped by wagons to Lucern, the terminus of the Delta branch of the Salt Lake route.

*Detroit district.*—The Ibex Co., operating the E. P. H. property, was the principal shipper of oxidized copper ore containing some gold and silver.

*Fish Springs district.*—Lessees on the Utah mine worked over the old dump of the property and shipped a small output of lead-silver ore in 1916. The mine has been a small producer for the last three years.

*Mount Nebo district.*—Six producers reported 427 tons of ore shipped from the region and containing a little gold, 1,903 ounces of silver, 100,822 pounds of lead, and 163,350 pounds of recoverable zinc, valued in all at $30,166, or an average per ton of $70.65. The principal production came from the Nebo Star and Eva properties, and smaller quantities were mined from the Emma and Mount Nebo properties.

*Tintic district.*—The total value of the metals produced in this district from 1869 to the end of 1916 was $169,326,248, distributed as follows: Gold, $31,688,389; silver, $78,762,811; copper, $25,063,297; lead, $32,341,622; zinc $1,470,129.

The larger part of the Tintic district is in Juab County and the remainder in Utah County.

*Mine production in Tintic district, Utah, 1915–16.*

| County. | Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Juab | 1915 | 32 | 282,953 | $902,335 | 3,999,847 | 5,347,474 | 29,301,537 | 2,149,857 | $5,509,820. |
| | 1916 | 44 | 348,737 | 834,841 | 4,848,047 | 7,085,704 | 35,425,153 | 2,414,089 | 8,535,763 |
| Utah | 1915 | 9 | 10,521 | 14,440 | 371,137 | 10,458 | 3,355,481 | 1,695,201 | 572,349 |
| | 1916 | 10 | 17,212 | 20,613 | 265,519 | 20,941 | 3,869,198 | 1,297,067 | 641,258 |
| | 1915 | 41 | 293,474 | 916,775 | 4,370,984 | 5,357,932 | 32,657,018 | 3,845,058 | 6,082,169 |
| | 1916 | 54 | 365,949 | 855,454 | 5,113,566 | 7,106,645 | 39,294,351 | 3,711,156 | 9,177,021 |
| Total, 1869–1916 | | | | 31,688,389 | 119,712,919 | 162,375,912 | 716,970,477 | 15,620,712 | 169,326,248 |

The value of the metals produced was distributed as follows: Gold, $855,454 in 1916, against $916,775 in 1915; silver, $3,364,727 in 1916, against $2,216,089 in 1915; copper, $1,748,234 in 1916, against $937,638 in 1915; lead, $2,711,311 in 1916, against $1,534,880 in 1915; zinc, $497,295 in 1916, against $476,787 in 1915.

With the completion and successful operation of the Tintic Milling Co.'s plant at Silver City, the problem of treating the low-grade ores seems to have been solved. In 1916 a number of companies shipped to this plant, which, at the writing of this report (June, 1917), is shipping its bullion containing principally silver and copper at regular intervals to eastern refineries. Altogether there were 54 producers in the district whose output was valued at $9,177,021, or an average value per ton of ore sold or treated of $25.08. In 1915 the output was valued at $6,082,169, or an average value per ton of $20.72. There was a large quantity of old mine-dump material of sufficient value to ship at the prevailing high prices for the metals. The following table gives the quantity and kinds of ore produced in the district in 1916, the number of producers, and the metallic content of each kind of ore:

*Mine production in Tintic district, Utah, in 1916, by kinds of ore.*

| Kind of ore. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Dry or siliceous | 26 | 79,194 | 8,198.22 | 891,103 | 1,409,369 | 140,575 | ..... |
| Copper | 21 | 115,043 | 20,455.22 | 1,091,323 | 5,325,609 | 1,782 | ..... |
| Lead | 36 | 164,089 | 12,716.17 | 3,127,043 | 366,307 | 39,020,686 | ..... |
| Zinc | 15 | 7,318 | ..... | ..... | ..... | 31,322 | 3,635,604 |
| Copper-lead | 2 | 78 | 12.96 | 4,097 | 5,360 | 17,770 | ..... |
| Lead-zinc | 1 | 227 | ..... | ..... | ..... | 82,216 | 75,552 |
| | ..... | 365,949 | 41,382.57 | 5,113,566 | 7,106,645 | 39,294,351 | 3,711,156 |

An interesting feature of the year was the opening of the Standard ore deposit in the eastern part of the district. At the close of 1916 the shipments[1] aggregated 3,420 tons of sulphide ore, containing principally lead and good silver values that averaged $29.59 per ton, or a total of $101,220. The net value after freight and smelter deductions were made aggregated $68,549, or $20.04 per ton. All of the ore was mined from the 1,600-foot level, which is opened by a 1,000-foot vertical shaft, from the bottom of which drifts have been driven with a winze connecting the lower workings where the ore was encountered. Owing to poor ventilation and the costly handling of the ore the company began work on a new vertical shaft about 1,700 feet northeast of the present shaft. The depth of this shaft will be 1,500 feet, and when it is completed a drift driven toward the ore body is expected to strike the ore in about 400 feet.[2]

Development was begun in search of ore at greater depth along the Colorado-Sioux-Iron Blossom zone as result of the discovery of a large body of copper ore at depth in the Iron Blossom property.

[1] Tintic Standard Mining Co. Ann. Statement for year ending Dec. 31, 1916.
[2] The manager of the Standard property reports sinking the new shaft into shipping ore at 1,174 feet early in July, 1917.

Active exploration of the Chief Consolidated properties was also carried on. This company located and purchased much ground to the east and north in the district.

The Eagle & Blue Bell property continued its shaft down to the 2,000-foot level, and in doing so opened one of the largest ore bodies in the district. The mine[1] produced 25,113 dry tons of lead ore, 430 tons of gold-silver ore, and 52 tons of zinc ore. There was a slight decrease in the ore handled on account of delays in delivery of machinery and the congestion of ores at the smelter. The average assay content of the lead ore shipped in 1916 was 0.038 ounce of gold and 13.6 ounces of silver per ton and 11.33 per cent of lead. Dividends amounting to $535,887.60 have been paid to stockholders since 1913, including $89,314.60 paid in 1916. The company's annual report says, in part:

> The main operating shaft was sunk from the 1,700 to water level, a distance of 300 feet, the water having been encountered at a depth of 2,018 feet from the collar of the shaft. A station was cut at the 1,875 level and considerable work done at that depth. Due to the very favorable developments on the upper levels, a station has not as yet been made on the 2,000 level, but this will be given attention in the near future.
>
> In sinking the shaft, lead-silver ore was encountered at a point 132 feet below the 1,700 level, and found to be more or less continuous for a distance of 90 feet. The developments on the 1,875 level would indicate that this ore occurrence is of considerable importance and means much to the property.

From the Centennial-Eureka mine[2] 51,381 tons of ore were shipped. In the meantime exploratory work in the vicinity of the old stopes and various leads were followed up successfully. The property of the Bullion Beck, controlled by the Centennial-Eureka Co. is operated mostly by lessees. Small quantities of zinc ore and lead ore were shipped to smelters, but no large new ore bodies have yet been found.

The Dragon Consolidated property produced milling ore containing silver and copper, which was shipped to the leaching works at Silver City.

There was also some oxidized copper ore shipped directly to the smelter.

In 1916 the Chief Consolidated mine[3] yielded 83,606 tons of ore which had a net value, after smelting, transportation, and sampling charges had been paid, of $1,315,441. The metal content of this ore was 8,331 ounces of gold, 1,739,004 ounces of silver, 18,356,937 pounds of lead, 1,795 pounds of copper, and 790,525 pounds of zinc. The average content was 0.1025 ounce of gold and 21.18 ounces of silver per ton, and 13.31 per cent of lead (in lead ore), 1.95 per cent of copper (in copper ore), and 30.62 per cent of zinc (in zinc ore). The zinc-lead ore contained 19.58 per cent of zinc, and 18.2 per cent of lead. The tonnage of ore was classified as 68,961 tons of lead ore, 13,127 tons of dry ore (with no lead or copper), 1,291 tons of zinc ore, and 227 tons of zinc-lead ore. The total average value per ton of the ore shipped in 1916 was $31.52, as against $20.55 in 1915, and its net value $18.64, as against $9.96. The total dividends paid since February 3, 1913, amounts to $532,518.15, including $176,481.05 paid

[1] Eagle & Blue Bell Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] United States Smelting, Refining & Mining Co. Eleventh Ann. Rept., for year ending Dec. 31, 1916.
[3] Chief Consolidated Mining Co. Eighth Ann. Rept., for year ending Dec. 31, 1916.

in 1916. The following extract is from the company's annual report:

The 1,000 ore system was worked between and at the 600 and 1,450 levels. Between the 700 and 800 levels made to the north in a broad, thin deposit pitching down at a slight angle; this section has supplied the main part of the product. A small but constant tonnage was derived from the 900, 1,000, 1,200, 1,400, and 1,450 levels on this system. * * *

On the 1,800 system the ore was followed up from the 1,800 and the 1,600 levels. This section has furnished a considerable part of the product. A continuation of this ore was developed on the 1,400 level. In order to continue the stoping of this ore where it makes below the permanent water level a pumping equipment will have to be installed.

At the Iron Blossom property [1] 33,529 dry tons of ore were shipped to smelters and 13,547 tons to the mill at Silver City. The smelting ore contained 4,601.90 ounces of gold, 923,468 ounces of silver, 3,099,300 pounds of lead, and 619,761 pounds of copper. The milling ore contained 1,048.59 ounces of gold, 129,836 ounces of silver, and 353,581 pounds of copper. The average assay of the milling ore was 0.077 ounce of gold and 9.58 ounces of silver per ton and 1.30 per cent of copper. The company report says:

During the early part of the year (1916) we struck ore in the winze which was sunk from the 600-foot level at the No. 3 shaft. This ore was discovered on the 900-foot level and was a good grade of copper ore. At the time of our last report we were unable to determine whether this ore would continue out in the channel, as the upper ore beds had done. This question is still to be determined, but from the present indications it would appear that it is a chute of ore which we have developed, commencing at the 900-foot and continuing down to the 1,200-foot level. On the 1,300-foot level we have been unable to locate this chute of ore, but in raising up about 75 feet it was located inclining northeasterly, explaining our failure to locate it on the 1,300-foot level. The discovery was so promising that we immediately started the main drift on the 1,700-foot level from the No. 1 shaft, which is now directly underneath the winze at No. 3 shaft. It is our intention to make connection from the 1,700-foot level to the bottom of the winze on the 1,300 level, a distance of 300 feet (as there is 100 feet difference in the elevation of the two shafts). When this connection is made it will afford a better means of extracting the copper ores and making a good circulation of air. * * *

We were hampered for a while the past year by our ore contracts expiring and the smelters refusing to take our ores, which naturally set this property back for a time.

The Lower Mammoth mine [2] produced 1,433 tons of silver-lead ore, 594 tons of copper ore, and 596 tons of zinc ore in 1916. On the 1,500 and 1,700 foot levels zinc ore was mined during the first half of the year by lessees, but when the price dropped work was discontinued. Zinc ore of 30 per cent grade is found in small lenses within a very large zone of low-grade zinc ore averaging about 12 per cent of zinc, estimated at 100,000 tons. A fairly large body of low-grade silver-lead ore was encountered on the 1,500-foot level and followed to the next level above.

The Victoria mine [3] produced 7,339 dry tons of ore in 1916 containing 1,893.67 ounces of gold, 79,047 ounces of silver, 657,416 pounds of lead, and 15,261 pounds of copper. This property is traversed by the Mammoth ore zone its entire length, a distance of approximately 1,700 feet.

[1] Iron Blossom Consolidated Mining Co. Ann. Rept. for year ending Dec. 1, 1916.
[2] Lower Mammoth Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[3] Bingham Mines Co. Eighth Ann. Rept. for year ending Dec. 31, 1916.

The May Day Co.[1] reports that the lead ore shipped during 1916 came from small ore bodies encountered in development work and in the cleaning of some stopes. The shipments of zinc ore from this mine are decreasing as compared with those of a year ago. During the summer the concentration mill was dismantled.

*West Tintic district.*—Work at the Scotia mine[2] was discontinued by the Chief Consolidated Co. at the expiration of its option on the property. It was decided that the property was too great a distance from the management headquarters to be operated to advantage.

In the Deseret Mountain section copper ores are being developed and shipped to the smelters. The properties are mentioned under Deseret Mountain district in Juab County.

### MILLARD COUNTY.

*Detroit district.*—The Copper Head property was a small producer of copper ore, and from present indications it will be a larger shipper in 1917.

### MORGAN COUNTY.

*Argenta district.*—Ore produced from the Carbonate Hill group, carrying lead and some silver, was shipped by lessees to the smelter.

*Morgan district.*—The Tunnel Hollow property is 7 miles from Morgan. A small shipment of ore containing 4 ounces of silver per ton and 6 per cent of copper was made in 1916.

### PIUTE COUNTY.

*Gold Mountain district,*—The Annie Laurie property yielded a small quantity of gold ore shipped by a lessee.

*Mount Baldy district.*—The Deer Trail property, which has been under development some time, made several small shipments of lead sulphide ore containing gold and silver. The ore occurs at the contact of quartzite and overlying limestone and is said to be about 12 feet thick. A tunnel has been driven in the quartzite and several raises made to the ore. From the Pluto property a few tons of copper ore carrying high values in silver were shipped to the smelter.

*Ohio district.*—All the shipments made from the district in 1916 were small. The best ore, rich in gold, was shipped by lessees from the Wedge property. There was also a small production from the Branch, Monroe, and Glen Aery claims.

### SALT LAKE COUNTY.

In Salt Lake County 81 operators produced 12,831,661 tons of ore in 1916, which was 3,113,659 tons more than was produced in 1915 by 67 producers. The total average value per ton of the ore for the gold, silver, copper, lead, and zinc content increased from $4.13 to $5.36, and the gold and silver average value per ton of this ore decreased from 42 cents to 39 cents. One mining company working with steam shovels at Bingham continues to be the principal producer, shipping its ore about 15 miles to Garfield for concentration.

[1] May Day Mining & Milling Co. Tenth Ann. Rept., for year ending Mar. 31, 1917.
[2] Chief Consolidated Mining Co. Semiannual Rept., Jan. 1 to June 30, 1916.

Most of the other producing mines yield ore which is shipped directly to the smelters in the Salt Lake and Tooele valleys by aerial tramway, wagon, and railroad.

*Big Cottonwood and Little Cottonwood districts.*—Production began in 1867. From that time to the end of 1916 these districts have a record of producing 381,292 tons of ore, valued at $23,602,304, which includes $481,918 in gold, $12,459,009 in silver, $1,424,440 in copper, $9,199,870 in lead, and $37,067 in zinc. The table of production by years is given to the end of 1914 in a recent report [1] of the Survey.

*Mine production in Big Cottonwood and Little Cottonwood mining districts, Utah, 1915–16.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 18 | 24,590 | $8,997 | 445,111 | 334,944 | 12,263,403 | 229,663 | $898,041 |
| 1916 | 31 | 41,960 | 21,414 | 755,980 | 819,192 | 15,061,273 | 60,746 | 1,767,738 |
| Increase or decrease, 1916 | | +17,370 | +12,517 | +310,869 | +484,248 | +2,797,870 | −168,917 | +869,697 |
| Total, 1867–1916 | | 381,292 | 481,918 | 12,222,833 | 8,692,833 | 168,689,233 | 299,213 | 23,602,304 |

In each of the last three years the value of the output of the districts has been double that of the preceding year. In 1916 the most important producer was the Cardiff mine, yielding lead ore, largely oxidized, and some sulphide. In the same vicinity, the Maxfield mine yielded principally sulphide ore, and at Alta, on the Little Cottonwood side of the district, the South Hecla and Michigan-Utah mines were producers of heavy shipments of oxidized silver-lead ores. Thirty-one producers in 1916 shipped directly to the smelters 41,960 tons of ore, containing $21,414 in gold, 755,980 ounces of silver, 819,192 pounds of copper, 15,061,273 pounds of lead, and 60,746 pounds of recoverable zinc, valued in all at $1,767,738, or an average value per ton of $42.13. Among the producers in the Big Cottonwood district were the Cardiff, Maxfield, Prince of Wales, Woodlawn, Iowa Copper, Howell, Carbonate, Evergreen, and Big Cottonwood Coalition. Those in Little Cottonwood district were the South Hecla, Alta Consolidated, Golconda, Wasatch Mines, Michigan-Utah, Albion, Peruvian, and Sells. Some old slag was hauled down the canyon to the smelters from the old Wellington dump.

The Cardiff mine, situated in the South Fork of Big Cottonwood Canyon, shipped to the smelter at Murray by wagon and motor trucks. During part of the year the rate was 100 to 125 tons of ore per day. Since October 1, 1915, dividends have been paid amounting to $500,000, of which $375,000 was distributed in 1916.

The opening of the faulted ore body of the Emma mine aroused considerable interest among mine operators. After locating the ore with diamond drills from the Bay City adit level the old shaft was unwatered. At a depth of 250 feet a drift was driven which disclosed a large body of ore similar to that mined in the early days.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 740, 1915.

In 1916 the South Hecla property[1] produced 7,961 dry tons of ore mined by the company and 1,097 dry tons of ore mined by lessees. Dividend No. 1, amounting to $39,437.95, was distributed to stockholders. The following statements are made in the company's report:

The total metal content of the ore produced during the year on company account and lessees' account is as follows: 300.942 ounces of gold, 181,112 ounces of silver, 1,454,372 pounds of lead, and 60,727 pounds of copper. * * *

During the year five blocks of ground were let to lessees, three of which are located on the Kate Hays vein, one on the Skipper vein, and one on the Bonanza vein. Two of the blocks which were let on the Kate Hays vein produced direct smelting ore during the year and have good showings of direct smelting silver-lead ore in their respective blocks at this time. * * * The block of ground let on the Bonanza vein produced direct smelting ore during the year, this ore being a silver-copper ore, and every indication is that this block will produce large quantities of high-grade direct smelting ore during 1917. The block of ground let on the Skipper vein produced during the year, the ore being silver-copper and of direct smelting grade. Indications are also very promising in this particular block. * * *

Shipments of ore were greatly retarded during March, April, and May on account of the almost impassable condition of the team road, and again during July, August, and September, on account of the congested condition of the local smelting companies; and during November and December the team roads were again in an almost impassable condition, there being too much snow for the use of wagons and not enough for sleighing.

At different points on the Quincy, Scott, and Dwyer levels large veins of milling-grade ores have been opened, but as our efforts have been to get direct smelting ore, we have not as yet explored these low-grade veins to any great extent.

The Wasatch Mines property is under development, consisting of 900 acres of mineral land, comprising the old Flagstaff, Columbus Consolidated, Superior Alta, and a number of other groups. A drain and transportation adit has been started, its ultimate length to be 5,000 feet, to drain the old Columbus ore bodies. About 3,000 feet of work will put the adit under the Columbus stopes, and if the adit is continued 2,000 feet farther it should drain the famous old Flagstaff and Emma mines.

*Smelter district.*—From the old smelter slag dumps and tailing dumps of the mills at Midvale there was shipped or treated 12,018 tons of material, valued at $116,084. All of the work was performed by lessees and reported by the companies owning the properties.

*Bingham or West Mountain district.*—The output of the Bingham district from 1865 to 1916, inclusive, is valued at $29,077,038 in gold, $33,369,357 in silver, $235,070,811 in copper, $46,106,414 in lead, and $3,209,173 in zinc, a total gross value of $346,832,793, out of which dividends (partly estimated) amounting to $63,357,502 have been paid. The table giving the production by years may be consulted in Mineral Resources for 1913, part 1, page 399.

[1] South Hecla Mining Co. Ann. Rept. for year ending Dec. 31, 1916.

*Mine production in Bingham or West Mountain district, Utah, 1915–16.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 44 | 9,693,184 | $2,507,477 | 2,704,833 | 176,593,414 | 80,004,006 | 5,491,359 | $39,223,793 |
| 1916 | 45 | 12,777,683 | 2,490,158 | 3,095,335 | 223,619,609 | 85,996,490 | 10,765,192 | 66,913,606 |
| Increase or decrease, 1916 | | +3,084,499 | −17,319 | +390,502 | +47,026,195 | +5,992,484 | +5,273,833 | +27,689,813 |
| Total, 1865–1916 | | | 29,077,038 | 45,629,704 | 1,433,225,191 | 984,568,830 | 35,449,244 | 346,832,791 |

The output of the district in 1916 was 12,777,683 tons of ore, against 9,693,184 tons in 1915, 7,800,661 tons in 1914, and 9,190,374 tons in 1913. The total metallic value of the ores in 1916 was $66,913,606, or an average value per ton of $5.24, against a total of $39,223,793, with an average value per ton of $4.05 in 1915. The value of the output of gold decreased from $2,507,477 in 1915 to $2,490,158 in 1916; silver increased from $1,371,350 to $2,036,730. The value of the copper increased from $30,903,848 to $55,010,424; lead, from $3,760,188 to $5,933,758; and zinc, from $680,929 to $1,442,536. Shipments of ore to the smelters amounted to 741,840 tons, against 539,939 tons in 1915, 532,130 tons in 1914, 655,634 tons in 1913, and 502,682 tons in 1912. The output of concentrating ores was 12,034,343 tons, against 9,152,918 tons in 1915, 7,268,472 tons in 1914, and 8,527,755 tons in 1913. The quantity of concentrates produced was 676,557 tons in 1916, against 523,753 tons in 1915, 435,903 tons in 1914, and 443,640 tons in 1913. The crude smelting ore in 1916 consisted principally of low-grade copper and lead sulphides and contained 53,694.26 ounces of gold, 1,831,216 ounces of silver, 23,779,433 pounds of copper, 47,641,559 pounds of lead, and 1,727,461 pounds of recoverable zinc, valued in all at $11,683,388, or an average value per ton of $15.75. Milling ores produced 676,557 tons of copper, lead, and zinc concentrates that contained 66,767.13 ounces of gold, 1,264,119 ounces of silver, 199,840,176 pounds of copper, 38,354,931 pounds of lead, and 8,646,183 pounds of recoverable zinc, valued in all at $55,177,751, or an average value per ton of $81.56.

*Mine production in Bingham district, Utah, in 1916.*

| Kind of ore. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Dry or siliceous | 2 | 110 | 13.72 | 511 | 2,668 | | |
| Copper | 28 | 12,343,559 | 92,101.65 | 1,412,106 | 220,076,715 | 4,662 | |
| Lead | 29 | 241,239 | 12,947.81 | 1,141,259 | 2,841,112 | 57,125,691 | |
| Zinc | 1 | 1,500 | | | | | 391,548 |
| Copper-lead | 2 | 272 | 201.26 | 2,709 | 21,189 | 26,699 | |
| Lead-zinc | 6 | 191,003 | 15,196.95 | 538,750 | 677,945 | 28,839,438 | 10,373,644 |
| | | 12,777,683 | 120,461.39 | 3,095,335 | 223,619,609 | 85,996,490 | 10,765,192 |

The Utah Copper property[1] produced 10,994,000 tons of concentrating ore by steam-shovel method in 1916, as compared with 8,494,300 tons for the year 1915. At the Magna concentrator 6,143,500 tons of this ore were milled and at the Arthur plant 4,850,000 tons, or an average of 16,785 tons and 13,253 tons, respectively, each day during 1916. In addition, 18,026 tons of ore, containing copper, lead, and zinc, were mined by underground methods from the "Sulphide" mine and shipped directly to smelting plants either by the company or by lessees. The gross production of copper from concentrates for 1916 was 196,752,631 pounds, and the shipments of crude ore contained an additional 664,849 pounds. After making smelter deductions, the net production was 187,531,824 pounds. In addition there were produced 47,648 ounces of gold and 461,596 ounces of silver. The total dividends paid by this company amount to $52,215,777.50, including $19,493,880 paid in 1916. The following paragraphs are taken from the company's annual report:

At the end of the year 1915 an ore-bearing area of 226.3 acres had been outlined by underground workings and churn drilling. No attempt was made during 1916 to add to this area, but the churn drilling done during the year increased the calculated average thickness of developed and partially developed ore from 480 feet to 524 feet. Taking this into account, the revised calculations show that previous to January 1, 1917, there had been developed in the property 424,524,258 tons of ore, averaging 1.415 per cent copper, of which quantity 270,000,000 tons are classed as fully developed and 154,524,258 tons as partially developed. Prior to January 1, 1917, there was mined from the entire property a total of 54,678,700 tons of ore, averaging 1.449 per cent copper, and, therefore, the total reserves remaining amount to 369,845,558 tons, averaging 1.41 per cent copper. The year's addition to reported reserves was 34,524,258 tons. Accordingly there was developed 23,530,258 tons in excess of the quantity mined during that period. The ore reserves will be increased from time to time whenever churn drilling can be done without interfering with other operations. * * *

The average grade of the ore milled at both plants (Magna and Arthur) was 1.435 per cent copper, as compared with 1.434 per cent copper for 1915. The average recovery at both plants was 62.34 per cent, corresponding to 17.90 pounds of copper per ton, as compared to 64.13 per cent, or 18.39 pounds of copper per ton, for the previous year. The low extraction was due principally to the unusually large tonnage milled, and only in small part to the presence of unrecoverable carbonates. The normal and metallurgically economical capacity of the two plants may be taken at about 20,000 tons per day, whereas during the past year a daily average of 30,038 tons was treated.

The cost of milling at Magna was 35.35 cents per ton and at Arthur 40.94 cents per ton, as compared with 30.91 cents and 39.02 cents, respectively, for the year 1915. The average cost of milling at both plants was 37.82 cents per ton, as compared with 34.02 cents for the previous year. The increase of 3.80 cents per ton was due solely to the higher costs of labor and supplies; in fact, only for these, the per ton cost would, on account of the greater tonnage treated, have been considerable lower than for 1915. * * *

The production for the year 1916 from all sources, by quarters, as compared to that of 1915, was as follows:

*Copper produced by Utah Copper Co. in 1915 and 1916.*

| Quarter. | 1915 | 1916 |
|---|---|---|
| | *Pounds.* | *Pounds.* |
| First | 26,415,995 | 36,673,007 |
| Second | 40,799,825 | 48,726,304 |
| Third | 44,766,841 | 61,181,870 |
| Fourth | 44,224,715 | 50,836,299 |
| | 156,207,376 | 197,417,480 |

[1] Utah Copper Co. Twelfth Ann. Rept., for year ending Dec. 31, 1916.

The average cost per net pound produced from concentrates, after making allowances for smelter deductions and after crediting precious metal values and miscellaneous income in Utah, was 6.918 cents, as compared with 6.612 cents for 1915. The value of the gold and silver recovered amounted to 0.653 cents per pound. Miscellaneous income in Utah, including that from the Bingham & Garfield Railway, amounted to 1.198 cents per pound. These costs include all expenses of smelting, transportation, refining, selling, all taxes, and all general, fixed, and maintenance charges of every kind. The average net cost, on the same basis, for all copper produced was 6.950 cents per pound. The table below shows a comparison, by years, of operating costs on concentrating ore based in the same way.

*Average cost per ton of ore of mining, transportation, and milling in property of Utah Copper Co., 1910–1916.*

| Year. | Tonnage. | Mining. | Transportation. | Milling. | Total. |
|---|---|---|---|---|---|
| 1910 | 4,340,245 | $0.4097 | $0.2978 | $0.4663 | $1.1738 |
| 1911 | 4,680,801 | .4479 | .3078 | .4168 | 1.1725 |
| 1912 | 5,315,321 | .4233 | .2848 | .4158 | 1.1239 |
| 1913 | 7,519,392 | .3288 | .2797 | .3676 | .9761 |
| 1914 | 6,470,166 | .3232 | .2782 | .3536 | .9550 |
| 1915 | 8,494,300 | .2441 | .2781 | .3402 | .8624 |
| 1916 | 10,994,000 | .2781 | .2792 | .3782 | .9355 |

In 1916 the Highland Boy property[1] produced 12,211,118 pounds of copper, 18,175,709 pounds of lead, 558,845 ounces of silver, and 21,727 ounces of gold.

*Average assay per ton of crude ore shipped from the Highland Boy mine, Utah, in 1916.*

| Material. | Dry ore. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounce.* | *Fine ounce.* | *Per cent.* | *Per cent.* |
| Copper-iron sulphide ore | 360,034 | 0.052 | 0.796 | 1.734 | ..... |
| Lead sulphide ore | 74,542 | .011 | 4.249 | .737 | 14.168 |

The Dalton & Lark property[2] produced 6,380 dry tons of lead sulphide ore and 22,512 dry tons of copper sulphide ore. In the old workings of the property and the Commercial mine lessees mined 8,760 dry tons of lead and copper ores. Altogether the ores shipped from these mines contained 2,173.39 ounces of gold, 260,852 ounces of silver, 992,924 pounds of copper, and 2,458,625 pounds of lead.

The Yosemite property[2] yielded 795 dry tons of lead ore and copper ore containing 33.72 ounces of gold, 5,848 ounces of silver, 220,644 pounds of lead, and 10,608 pounds of copper. From the Cluster workings of this property lessees produced 245 dry tons of ore on which $1,811.26 was paid as royalty to the company.

At the mines of the United States Mining Co.[3] development and exploration work opened up ore ahead of extraction. There were shipped by these mines 109,586 tons of lead ore and 46,017 tons of copper ore. The company's annual report gives further information a follows:

The improvements on the Niagara tunnel, including the installation of a pneumatic haulage system, are now completed. The haulage system has proven

[1] Utah Consolidated Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] Bingham Mines Co. Eighth Ann. Rept., for year ending Dec. 31, 1916.
[3] United States Smelting & Refining Co. Eleventh Ann. Rept., for year ending Dec. 31, 1916.

so successful that a similar installation was made on the 400 level from the Galena shaft The Niagara tunnel installation handles the whole output of the mines and is adequate for larger operations if such should be decided on in future. It eliminates the necessity of operating the aerial tramway, and the latter has been dismantled and shipped to the Stowell mine in California, where it is now in successful operation. Mining and exploration work have been simplified by the installation of the Niagara haulage system, the costs have been materially reduced, and efficiency increased.

The Utah Apex Co.,[1] according to the report for the fiscal year, received for ores produced $1,642,170 after smelting and freight charges were deducted. In 1915 the net returns were $827,600. The mine was the chief producer of lead in Utah during 1916, most of the product consisting of milling and shipping ore from the upper levels and from the Parvenu ore body. This ore body continues below the thirteenth level. Increased profits during the year came largely from the opening of a copper ore body in the Parnell and York beds.

The Utah Metal & Tunnel property,[2] with which the output of the Bingham & New Haven mine is combined, produced in 1916 crude ore and concentrate amounting to 68,081 dry tons, containing 17,934 ounces of gold, 388,757 ounces of silver, 1,761,520 pounds of copper, and 6,301,670 pounds of lead, valued in all at $1,499,267.69. Dividends during 1916 amounted to $342,472.50. The average cost of mining the ore was $2.51 a ton, and milling $1.11 a ton. During 1916 an oil flotation unit was added to the mill to treat low-grade iron-copper ore, of which the mine is said to have a large quantity.

### SAN JUAN COUNTY.

*Big Indian district.*—The Big Indian property in this district, situated about 6 miles due south of La Sal post office, was actively developed, and the construction of a copper leaching plant was commenced. The plant is expected to treat 300 tons of ore each 24 hours, and will be ready to operate the latter part of 1917.

### SUMMIT AND WASATCH COUNTIES.

The principal producing area is the Park City region, which embraces the Blue Ledge, Snake Creek, and Uinta districts. All but the first-named were credited with an output in 1916 of gold, silver, copper, lead, and zinc, valued at $5,373,405. This value added to the value of the production of metals since 1870 amounts to the sum of $163,501,921, which includes $4,256,531 in gold, $96,782,437 in silver, $4,567,071 in copper, $53,475,354 in lead, and $4,420,528 in zinc. The total value of dividends from the district for the period 1870–1916 is $41,906,753.

[1] Utah Apex Mining Co. Ann. Rept. for year ending Aug. 31, 1916.
[2] Utah Metal & Mining Co. Second Ann. Rept., for year ending Dec. 31, 1916.

*Mine production in Park City mining region, Utah, 1915–16.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 19 | 263,342 | $86,980 | 3,754,598 | 2,287,172 | 49,350,377 | 7,771,350 | $5,673,931 |
| 1916 | 20 | 300,598 | 111,236 | 2,900,718 | 1,512,578 | 33,233,794 | 5,136,353 | 5,373,405 |
| Increase or decrease, 1916 | | +37,256 | +24,256 | −853,880 | −774,594 | −16,116,583 | −2,634,997 | −300,526 |
| Total, 1870–1916 | | | 4,256,531 | 132,362,372 | 29,743,248 | 1,218,729,299 | 60,989,429 | 163,501,921 |

In 1916 the output of ore was 300,598 tons, as against 263,342 tons in 1915. The crude ore shipped directly to the smelters consisted of mixed lead carbonates and sulphides aggregating 50,276 tons and containing 3,810.49 ounces of gold, 2,168,370 ounces of silver, 1,103,528 pounds of copper, 19,832,918 pounds of lead, and 12,438 pounds of recoverable zinc, valued in all at $3,147,163, or an average value per ton of $62.60. The remainder of the ore (123,655 tons) was milled, the bulk of it producing 31,196 tons of concentrates, including those from 125,196 tons of creek tailings. The concentrates contained 1,551.67 ounces of gold, 728,461 ounces of silver, 397,913 pounds of copper, 13,158,028 pounds of lead, and 5,123,915 pounds of zinc, valued in all at $2,203,797, or an average value per ton of $70.64. In 1915 the average value per ton of shipping ore was $53.94 and of concentrates $64.48.

In 1916 the Daly-Judge mine[1] produced 65,951 tons of ore, of which 61,687 tons, dry weight, were concentrated, yielding 10,019 tons of lead concentrate and 6,129 dry tons of zinc concentrate. Only 2,929 tons of the zinc concentrate were sold, the remainder, 3,200 tons, being held for treatment in the new electrolytic zinc plant. The ratio of concentration was 6.17 to 1 for the lead concentrate and 4.7 to 1 for all products combined. Construction was started April 25 on the electrolytic zinc plant, which is to have a capacity of 15 tons of refined zinc a day. The first ore was fed to the roaster February 1, 1917. The plant is in Deer Valley, 1 mile east of Park City. The process as described in the company's annual report is as follows:

From the receiving bins, the concentrates are elevated to the top of the roaster building, and descend through a Standard Wedge zinc furnace.

The roasted product is elevated to bins which feed the leaching plant.

Leaching is accomplished by agitating the roasted concentrates with an 8 per cent sulphuric-acid solution in Deveroux tanks.

The leach-tank product is discharged to classifiers which remove the coarser insoluble material, the latter being collected in storage bins. From the classifiers the solution and fine slimes are discharged to a Dorr thickener tank, the slimes being settled and discharged to an Oliver filter, and the overflowing solution passes on to the purification apparatus.

The slimes collected on the Oliver filter are stored with the material discharged from the classifiers. These materials carry the lead and silver values and are disposed of by sale to the lead smelters.

In leaching the roasted concentrate, copper, cadmium, and other impurities are dissolved as well as the zinc. It is impossible to recover the zinc from these solutions until these impurities are removed. The removal of impurities is accomplished by passing the solution through tube mills filled with zinc shot,

[1] Judge Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1916.

the copper, etc., being thrown out as sponge metal which is collected on filter leaves.

The filtered solution is collected in large tanks, which feed the electrolytic cells.

In the cell room there are 120 cells at present installed, with room provided for an additional 16. These are, at present, arranged in two groups of 60 each, and each group is energized by means of its own 5,000 ampere by 250 volts generator.

Each cell carries 12 aluminum disks, 5 feet in diameter, mounted on a shaft so arranged that it can be rotated slowly. Alternating with the aluminum cathode disks are 13 lead anodes, which are supported independently of the shaft.

Current, passing from the lead anodes to the aluminum cathodes, carries the zinc with it and is deposited upon the rotating disks. In the course of about three weeks each shaft carrying the 12 disks collects some 5,000 pounds of zinc. The loaded shaft is removed, the zinc stripped, and the shaft is reassembled and returned to the cell.

The stripped zinc is melted down, cast into cakes, and ready for market.

As the zinc is removed in the cell room the sulphuric acid with which it was combined in the leaching plant is again set free and becomes available for leaching another batch of roasted concentrates.

The Snake Creek adit, acquired by the company in 1916, has been driven a total distance of 14,500 feet. Work was discontinued early in the year on account of high cost of labor and material. Dividends paid to stockholders amount to $1,155,000, including $435,000 paid in 1916. The quantity and content of the ore shipped and of profits from ore milled are given in the company's report, as follows:

*Average content of crude ore and concentrates of Judge Mining & Smelting Co., Utah, in 1916.*

| Kind of material. | Dry ore. | Gold (per ton). | Silver (per ton). | Copper. | Lead. | Zinc. | Iron. | Sold for— |
|---|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounce.* | *Fine ounces.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | |
| Crude ore shipped | 4,164 | 0.026 | 30.05 | 1.26 | 19.34 | 9.69 | 6.75 | $34.11 |
| Lead concentrates shipped | 10,019 | .037 | 28.93 | 1.18 | 31.33 | 8.85 | 19.45 | 51.12 |
| Zinc concentrates shipped | 2,929 | .019 | 21.47 | ..... | 4.38 | 44.58 | 6.54 | 63.22 |

The Silver King Coalition, as a dividend payer, with a total of $14,334,885 to its credit, has a better record than its neighbor, the Ontario. During 1916 the stockholders received $750,000. Although shipments of silver-lead ore and concentrate were not so great in 1916 as in the preceding year, the earnings have been better. It is reported that the Silver King ore deposits have been followed for 8,000 feet, with an average production of 59.26 tons per running foot and an average net value per ton of $38.54. The oil-flotation plant at the concentration mill on the property was completed in 1916, and caused a better saving of the values. Considerable work was performed in sinking the Silver Hill shaft from the Alliance adit. The shaft will cut the contact at between 1,000 and 1,200 feet.

The Silver King Consolidated,[1] according to its own ore statement, sold 10,049 tons of ore containing an average of 0.042 ounce of gold, 43.52 ounces of silver, 26.13 per cent of lead, 1.13 per cent of copper, for $49.57 per ton. The Grasselli zinc concentrator, which the company has purchased and reequipped, was operated experimentally, the oil-flotation process being used. Toward the close of

[1] Silver King Consolidated Mining Co. Ann. Rept. for fiscal year ending Feb. 1, 1917.

the year it produced 32.8 tons of concentrate containing an average of 0.045 ounce of gold and 50.8 ounces of silver per ton, 32.5 per cent of lead, 1.41 per cent of copper, and selling for $71.91 per ton. Dividends disbursed since the year 1914 amounted to $1,109,418.08, including $294,561.56 in 1916. A new aerial tramway 10,200 feet long, having a carrying capacity of 20 tons per hour, was completed in 1916. This cuts costs of transportation between the mine and its mill, where sampling of the crude shipping ore takes place. At the present time the property is developed by a shaft 1,800 feet deep and by drifts at various levels. A tunnel was started in 1916 following a straight line projected through territory of the company for a distance of 14,000 feet and attaining a vertical depth of 1,800 feet. About 1,700 feet of this tunnel was finished at the end of January, 1917. The ore production in 1916 came principally from the "carbonate" ore beddings between the 1,500-foot and 1,625-foot levels.

At the Daly West mine[1] comparatively little ore was produced. It maintained the good grade of recent years, though it was not as rich as the ore of the earlier years of production. Development was reported successful in the 1,700, 1,900, and 2,000 foot levels of the mine. Ore sales, including some lead and zinc concentrates, amounted to $237,681 in 1916.

## TOOELE COUNTY.

The production of 124,695 tons of ore by 48 producers in 1916 was 12,804 tons greater than the output by 37 producers in 1915. The average value per ton of the ore increased from $15.29 in 1915 to $23.48 in 1916, and the gold and silver value per ton from $3.45 to $4.82. The total value of the ore sold or treated, containing gold, silver, copper, lead, and zinc was $2,928,402, against $1,710,616 in 1915. The county output consisted of 913.42 ounces of gold, valued at $18,882; 884,403 ounces of silver, valued at $581,937; 2,836,678 pounds of copper, valued at $697,823; 18,727,671 pounds of lead, valued at $1,292,209; and 2,519,172 pounds of recoverable zinc, valued at $337,569. The increases were: Gold, $3,449; silver, 152,320 ounces in quantity and $210,771 in value; copper, 579,474 pounds in quantity and $302,812 in value; lead, 2,122,717 pounds in quantity and $511,776 in value; and zinc, 1,321,000 pounds in quantity and $188,996 in value. The county output was 112,080 tons of lead ore, of which 62,400 tons were milled. The crude lead ore shipped was 39,546 tons, of which 8,401 tons were oxidized and 31,145 tons were sulphide. The zinc ore produced was 4,758 tons, most of which (4,747 tons) was of shipping grade and an oxidized product. The quantity of dry or siliceous ore increased from 15 tons in 1915 to 823 tons in 1916. The output of copper ore was 4,910 tons, all of which was oxidized, and the copper-lead ore was 2,074 tons, all of which was oxidized. There were also 50 tons of oxidized lead-zinc ore. There were shipped directly to the smelters 51,780 tons of ore, which contained $10,280 in gold, 554,557 ounces of silver, 1,706,908 pounds of copper, 10,557,470 pounds of lead, and 2,513,065 pounds of recoverable zinc, having a total value of $1,860,294, or an average value per ton of $35.93. Concentrating and jigging plants produced

[1] Daly West Mining Co. Ann. Rept. for year ending Dec. 31, 1916.

27,642 tons of concentrates from the treatment of 62,400 tons of ore and yielded $5,163 in gold, 315,669 ounces of silver, 1,045,217 pounds of copper, and 7,583,983 pounds of lead, valued in all at $993,291, or an average value per ton of $35.93.

*Camp Floyd district.*—The Daisy mine and mill, in the West Dip section, were operated during part of 1916. Some gold bullion and precipitates were shipped from cyaniding the ores.

*Clifton district.*—The Seminole property continued to ship copper ore and small quantities of tungsten ore during development. A small lot of lead ore was produced from the Midland property.

This district has been handicapped for years in not having cheaper transportation facilities. Work has finally been started on the 43-mile railroad between Wendover, on the Western Pacific Railroad, and Gold Hill in this district. Most of the properties are but partly developed in this and neighboring districts, as everything had to be hauled 56 miles, at a cost of $12 per ton, over wagon roads which were at times almost impassable. The principal property in the district is the Western Copper Co., operating the Gold Hill, Cane Springs, Alvarado, and Calaveras groups. It is reported to have 100,000 tons of copper ore blocked out, assaying 4 to 5 per cent of copper with some gold and silver. This company also has a large deposit of carbonate lead ores containing about 15 per cent of lead and 12 ounces of silver per ton. Other properties more or less developed are the Ida Lull claims, Garrison Monster, Royal, and Chester or Evan's groups on Dutch Mountain.

*Columbia district.*—Two properties, the Sultana and Old Sharp, produced ore in 1916. Most of the development work was performed by lessees and should show good returns for 1917.

*Dugway district.*—Renewed activity in this district promises well for the future. The Laurel, Metallic Hill, and Golconda properties were producers of small quantities of lead ore carrying silver, which was hauled by wagon and truck to the railroad 40 miles distant.

*Erickson district.*—The O. K. property during development work continued to produce very rich silver ore containing some gold and a little copper.

*North Tintic district.*—With the increase in the price of zinc, the low-grade ore of the Scranton mine was shipped with a small margin of profit by lessees. There was also some ore shipped from the New Bullion mine.

*Ophir district.*—Twenty properties yielded 94,453 tons of ore. The larger part of this tonnage is from three big mines, the most important of which is equipped with a milling plant at which most of this ore was concentrated. There were shipped directly to the smelters 41,189 tons of crude ore, which included 996 tons of zinc ore containing 640,251 pounds of recoverable zinc. The producers of the district were the Ophir Hill, Cliff, Hidden Treasure, Buffalo Consolidated, Brooklyn, Commodore, Surprise, Kearsarge, Chloride Point, Mono, Queen of the Hills, Utah Queen, and Wandering Jew.

*Rush Valley district.*—Reports received from 10 producers show the production of 24,710 tons of ore and some slag, containing $9,081 in gold, 108,841 ounces of silver, 118,943 pounds of copper, 5,413,042 pounds of lead, and 136,615 pounds of recoverable zinc, valued in all at $501,764, or an average value per ton of $20.31. Of

this ore, 14,203 tons were concentrated and yielded lead concentrates, and 5,429 tons of ore were shipped directly to the smelter. The principal producer was the Bullion Coalition property, and important shipments were made from the New Stockton and the Galena King, with smaller shipments from the Lookout and Southport properties. Some slag continued to be shipped from the old Waterman smelter dump.

*Silver Islet district.*—Some development work was carried on in the district, during which a small quantity of ore was produced and shipped.

*Third Term district.*—Two properties yielded a small quantity of lead-copper ore, which was shipped directly to the smelter.

*Timpie Canyon district.*—This region is in the north end of the Stansbury Range, 38 miles due west of Salt Lake. One car of low-grade oxidized zinc ore was shipped from the Climax property, situated at the head of the canyon, to an eastern plant. The lowest assay on the ore taken out was 24 per cent of zinc and the highest 42 per cent. The ore was found on the dump of the Climax claim taken out in mining some lead ore.

### UINTA COUNTY.

*Carbonate district.*—A small quantity of copper ore was shipped from the district in 1916.

*Green River district.*—Numerous tests were made trying various apparatus for the saving of fine gold. No production was reported, except from small operations.

### UTAH COUNTY.

Eighteen operators reported the production of 18,111 tons of ore in 1916, against 10,934 tons of ore produced by 18 operators in 1915. The total value of the output in 1916 was $703,569, against $590,591 in 1915. The total average value per ton of the ore decreased from $54.01 in 1915 to $38.85 in 1916 and the gold and silver value per ton from $18.99 to $12.60. Most of the ore produced (14,670 tons) was of shipping grade, and the remainder (1,965 tons) was milled, and produced concentrate containing gold, silver, copper, and lead. There were also 1,476 tons of ore leached containing gold, silver, and copper.

*American Fork district.*—Six operators reported the production of 868 tons of ore in 1916. This is about double the production in 1915. The total value of the output in 1916 was $61,332, against $18,242 in 1915. The average value per ton increased from $44.17 in 1915 to $70.66 in 1916. The principal producer was the Pacific Gold property, on which there was a mill erected and completed within the year, but the production of concentrates did not begin until 1917. The other producers were the Dutchman, Miller, Mineral Flat, and Red Cloud properties.

*Mine production in American Fork district, Utah, 1915–16.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 9 | 413 | $1,013 | 8,039 | 4,018 | 259,499 | 2,050 | $18,242 |
| 1916 | 6 | 868 | 895 | 48,360 | 31,189 | 250,460 | 27,319 | 61,332 |
| Increase or decrease, 1916 | ..... | +455 | −118 | +40,321 | +27,171 | −9,039 | +25,269 | +43,090 |
| Total, 1870–1916 | ..... | 60,607 | 269,369 | 1,852,575 | 143,461 | 27,944,806 | 46,911 | 3,804,711 |

The Pacific property,[1] under lease to the Fissures Exploration Co., shipped 373 tons of lead sulphide ore and 402 tons of copper sulphide ore during 1916. From the operation of the 70-ton table concentrator erected in 1916 two cars of lead concentrate were shipped in January, 1917. In places the vein under development is 26 feet wide and is said to average $55 per ton in copper, silver, and gold. One 51-ton car of this ore shipped assayed 3.25 per cent of copper, 124.4 ounces of silver, 0.0725 ounce of gold, bringing the operators $93.88 gross per ton. About 5,000 tons of mill ore is developed.

The mill built for the treatment of Pacific ores began operations the latter part of December. It is electrically driven, equipped with 2 sets of rolls, 2 trommels, Callow screen, 3 elevators, 2 roughing tables, 2 sand tables, and 2 double deck slime tables.

*Santaquin district.*—The Union Chief and Blue Eagle properties each produced a small tonnage of lead ore.

*Tintic district.*—In 1916 the producers on the Utah County side were the Beck Tunnel, Colorado, May Day, Sioux, Standard, Uncle Sam, Utah group, and Yankee Consolidated. The production of the district is reviewed under Juab County, under which the operations of the more important properties in 1916 are described.

## WASHINGTON COUNTY.

*Bull Valley district.*—During 1916 important development work was continued on the Bull Valley property. The production reported was likely from a small clean-up of the operations of lessees of the previous year.

*Harrisburg district.*—The Adah Copper Co. operated the Burg mine during 1916, and produced some copper ore, carrying small values in silver.

*Tutsagubet district.*—Five producers reported the production of 53 tons of ore, carrying chiefly copper. The largest production came from the Dixie mine and a small output was reported from the Paymaster property. All of the ores in the district carry copper, which is the chief metal of value.

[1] Pacific Gold Mining & Milling Co. Financial Statement Feb. 3, 1917.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN NEVADA.

(MINES REPORT.)

By V. C. HEIKES.

## PRODUCTION.

### GENERAL STATEMENT.

Nevada mines in 1916 produced 5,941,165 tons of ore, which, with placer bullion, contained gold, silver, copper, lead, and zinc valued at $49,946,424. This total represents an increase in value of $15,394,988, as compared with $34,551,436 in 1915 from 5,118,620 tons of ore and from placer bullion. There were 779 producers of ore and bullion in 1916, of which 65 were placers, against 696 lode producers and 103 placers in 1915. The value of the production of copper represented nearly 52 per cent of the total value, or $25,858,736, an increase of $13,847,371. There was also an increase in the value of the production of recoverable zinc, from $3,022,680 in 1915 to $4,347,387 in 1916. The largest part of the total increase in 1916 was in the value of copper. Silver, zinc, and lead also added considerably to the total value, but gold decreased from $11,404,300 in 1915 to $8,866,237 in 1916. The gold production from placer mines decreased from $395,319 in 1915 to $354,313 in 1916. Fourteen mining companies in Nevada, some of which owned property in other States, paid dividends in 1916 amounting to $12,097,246.

*Mine production of gold, silver, copper, lead, and zinc in Nevada, in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc content. | Total value.[a] |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 799 | 5,118,620 | $11,404,300 | 14,459,840 | 68,636,370 | 16,637,277 | 24,376,450 | $34,551,436 |
| 1916 | 779 | 5,941,165 | 8,866,237 | 13,837,525 | 105,116,813 | 25,637,278 | 32,443,189 | 49,946,424 |
| Increase or decrease, 1916 | ..... | +822,545 | −2,538,063 | −622,315 | +36,480,443 | +9,000,001 | +8,066,739 | +15,394,988 |
| Total, 1904–1916 | ..... | 39,885,378 | 154,578,672 | 144,970,417 | 621,074,167 | 133,931,339 | 113,679,704 | 356,665,638 |

[a] Includes placer production.

## ORE.

Mines in Nevada produced 5,941,165 short tons of ore in 1916, an increase of 822,545 tons, compared with the production of 1915. The average total metallic value per ton was $8.35, against $6.67 in 1915, but the value per ton in gold and silver decreased from $3.58 in 1915 to $2.96 in 1916. The largest decrease in production of ore was in Eureka, Esmeralda, Nye, and Storey counties. The output of dry or siliceous ores decreased from 1,812,653 tons in 1915 to 1,688,661 tons in 1916. Under this classification is included 817,100 tons of low-grade siliceous gold ores, averaging $5.89 in gold and 0.86 ounce of silver per ton, and carrying small quantities of copper and lead. Gold and silver mixed ores, dry or siliceous in character, aggregated 13,330 tons and averaged per ton $4.16 in gold and 6.19 ounces of silver. The output of siliceous silver ores in 1916 amounted to 858,231 tons, mined by 117 producers, averaging per ton $2.77 in gold and 13.94 ounces of silver, and carrying small quantities of copper and lead, as against 836,791 tons mined in 1915 by 112 producers, whose ore averaged per ton $3.14 in gold and 15.63 ounces of silver. A total of 137,120 tons of oxidized iron manganese ore, which was produced entirely in the vicinity of Pioche, is included in the silver ore. This ore contained lead and small quantities of gold and silver and was particularly valuable as flux.

The production of copper ore by 182 operators amounted to 4,146,956 tons and contained 56,880.78 ounces of gold, 384,393 ounces of silver, 104,599,510 pounds of copper, and 59,675 pounds of lead, the value per ton averaging $6.55. The output of lead ores increased from 15,508 tons in 1915 to 37,513 tons in 1916. Lead ore of smelting grade amounted to 19,176 tons. In this smelting ore the oxidized ore, largely carbonates, increased in quantity from 5,788 tons in 1915 to 14,428 tons in 1916, which averaged $3.82 in gold, 21.14 ounces of silver, 6.70 pounds of copper, 395.86 pounds of lead, and $46.69 in total value per ton. The smelting sulphide ores of lead amounted to 4,748 tons and averaged $1.39 in gold, 13.15 ounces of silver, 8.98 pounds of copper, 813.51 pounds of lead, and $68.38 in total value per ton. Zinc ores of shipping grade increased from 24,816 tons in 1915 to 31,886 tons in 1916. The oxidized and carbonate zinc ores amounted to 31,835 tons, from which was recovered an average of 624.09 pounds of zinc per ton. The zinc sulphide ores amounted to 51 tons and produced 409.21 pounds of zinc per ton. Production of copper-lead ores increased from 1,485 tons in 1915 to 2,846 tons in 1916, all of which was shipped to smelters. Of this ore, 2,436 tons were oxidized or carbonate copper-lead ores, averaging 23 cents in gold, 17.20 ounces of silver, 65.11 pounds of copper, 313.37 pounds of lead, and having a total value per ton of $49.19, and 410 tons were sulphide copper-lead ores, averaging 15 cents in gold, 21.69 ounces of silver, 101.46 pounds of copper, 285.59 pounds of lead, and having a total value per ton of $59.09. There were 33,303 tons of lead-zinc ore produced, the largest part of which, or 32,526 tons, was concentrated into a lead concentrate, a zinc concentrate, and a lead-zinc concentrate. Only 777 tons of lead-zinc ore was of shipping grade.

The output of milling ores was 5,490,862 tons, of which 1,424,135 tons were treated by amalgamation and cyanidation, and the remainder, 4,066,727 tons, by concentration followed by smelting. The

ores and tailings treated by cyanidation—1,292,244 tons of the former and 75,005 tons of the latter—produced an average per ton of $4.44 in gold and 8.27 ounces of silver. The ores amalgamated, 131,891 tons, yielded bullion averaging per ton $5.86 in gold and 0.19 ounce of silver.

*Mine production of gold, silver, copper, lead, and zinc in Nevada in 1916.*

| Source of production. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Placers | 65 | ..... | 17,139.89 | 5,744 | ..... | ..... | ..... |
| Dry or siliceous ore | 356 | 1,688,661 | 351,420.33 | 12,751,911 | 167,186 | 8,104,649 | ..... |
| Copper ore | 182 | 4,146,956 | 56,880.78 | 384,393 | 104,599,510 | 59,675 | ..... |
| Lead ore | 178 | 37,513 | 3,046.56 | 444,585 | 144,963 | 12,044,727 | ..... |
| Zinc ore | 50 | 31,886 | ..... | 21,613 | 4,941 | 448,513 | 19,888,817 |
| Copper-lead ore | 15 | 2,846 | 29.60 | 50,803 | 200,213 | 880,477 | ..... |
| Lead-zinc ore | 12 | 33,303 | 387.05 | 178,476 | ..... | 4,099,237 | 12,554,372 |
| | ..... | 5,941,165 | 428,904.21 | 13,837,525 | 105,116,813 | 25,637,278 | 32,443,189 |

*Ore sold or treated in Nevada in 1916, in short tons.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|
| Churchill | 116,915 | 16 | 2 | ..... | 10 | ..... | 110,943 |
| Clark | 30,999 | 2,415 | 17,082 | 29,675 | 57 | 23,146 | 103,374 |
| Douglas | ..... | 84 | ..... | ..... | ..... | ..... | 84 |
| Elko | 28,632 | 7,102 | 1,243 | 2,092 | 2,260 | ..... | 40,729 |
| Esmeralda | 360,769 | 27,560 | 982 | ..... | ..... | 40 | 389,351 |
| Eureka | 15,995 | 308 | 5,796 | 83 | ..... | ..... | 22,082 |
| Humboldt | 108,250 | 1,214 | 215 | ..... | 4 | ..... | 109,683 |
| Lander | 11,211 | 3,815 | 1,073 | ..... | ..... | ..... | 16,099 |
| Lincoln | 137,572 | 9,530 | 4,903 | ..... | 40 | 10,108 | 162,153 |
| Lyon | 11,634 | 19,788 | ..... | ..... | ..... | ..... | 31,422 |
| Mineral | 244,450 | 20,836 | 894 | ..... | 3 | ..... | 266,183 |
| Nye | 564,223 | 34 | 193 | ..... | ..... | ..... | 564,450 |
| Ormsby | 105 | 2 | ..... | ..... | ..... | ..... | 107 |
| Storey | 63,187 | ..... | ..... | ..... | ..... | ..... | 63,187 |
| Washoe | 1,204 | 671 | 3,186 | ..... | ..... | ..... | 5,061 |
| White Pine | 215 | 4,053,581 | 1,944 | 36 | 472 | 9 | 4,056,257 |
| | [a] 1,688,661 | 4,146,956 | 37,513 | 31,886 | 2,846 | 33,303 | 5,941,165 |
| Average value per ton in gold and silver | $9.27 | $0.34 | $9.48 | $0.44 | $11.96 | $3.77 | $2.96 |

[a] Includes 817,100 tons of gold ore, 13,330 tons of gold and silver ore, and 858,231 tons of silver ore. The last named includes 137,120 tons of oxidized iron ore.

## GOLD.

The mine production of gold was valued at $8,866,237 in 1916, a decrease of $2,538,063, as compared with 1915. Esmeralda County is credited with the largest production of gold, amounting to $2,684,688, against $4,689,260 in 1915. Nearly all of this output was from the Goldfield district, which produced $1,738,227 less than in 1915. The counties having substantial increases in gold were Storey, Clark, Elko, and White Pine. The largest decreases were in Esmeralda, Nye, and Humboldt counties. Placer gold was produced in greatest quantity in Nye, Lander, and Eureka counties. The value of the placer gold was $354,313, against $395,319 in 1915. Ore was milled in 1916 by

amalgamation in 12 counties and by cyanidation in 14 counties. From these two methods of treatment $6,842,403 in gold was produced from 1,424,135 tons of ore and 75,005 tons of old tailings. The total average gold recovery from ore and tailings was $4.56 per ton. The gold extracted by amalgamation averaged $5.86 a ton of ore treated, as against $6.86 a ton in 1915, and by cyanidation it averaged $4.44 a ton of ore and tailings treated, as against $5.20 in 1915. From all concentrates, including siliceous, copper, lead-zinc, and iron sulphide concentrates, 48,459.53 ounces of gold were produced, against 40,089.01 ounces in 1915. The gold in dry or siliceous concentrates was 13,235.26 ounces in 1916, against 12,986.79 ounces in 1915, and was principally from iron sulphide concentrates; the copper concentrates contained 34,482.46 ounces, against 26,530 ounces in 1915; the lead concentrates, 430.81 ounces, against 572.22 ounces in 1915; the zinc concentrates 291 ounces; and the copper-lead concentrates 20 ounces.

*Mine production of gold in Nevada in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | | Total. |
|---|---|---|---|---|---|---|---|
| | | Dry or siliceous ore. | Copper ore. | Lead ore. | Copper-lead ore | Lead-zinc ore. | |
| Churchill | ..... | 13,732.42 | ..... | 0.04 | 1.69 | ..... | 13,734.15 |
| Clark | ..... | 14,027.62 | 588.45 | 296.42 | .17 | ..... | 14,912.66 |
| Douglas | 4.26 | ..... | .05 | ..... | ..... | ..... | 4.31 |
| Elko | 2.32 | 13,445.02 | 154.06 | 29.86 | 17.94 | ..... | 13,649.20 |
| Esmeralda | ..... | 109,790.76 | 20,032.42 | 48.60 | ..... | ..... | 129,871.78 |
| Eureka | 501.79 | 3,568.55 | .29 | 1,480.49 | ..... | ..... | 5,551.12 |
| Humboldt | 347.04 | 18,873.89 | 10.73 | 27.80 | 4.96 | ..... | 19,264.42 |
| Lander | 7,435.14 | 1,673.25 | 95.00 | 561.63 | ..... | ..... | 9,765.02 |
| Lincoln | ..... | 838.26 | 129.25 | 304.21 | .73 | 387.05 | 1,659.50 |
| Lyon | 112.62 | 3,816.89 | 16.25 | ..... | ..... | ..... | 3,945.76 |
| Mineral | 35.94 | 34,124.76 | 68.54 | 70.28 | 1.06 | ..... | 34,300.58 |
| Nye | 8,667.11 | 112,444.49 | ..... | 102.32 | ..... | ..... | 121,213.92 |
| Ormsby | ..... | 15.89 | .56 | ..... | ..... | ..... | 16.45 |
| Storey | ..... | 23,371.75 | ..... | ..... | ..... | ..... | 23,371.75 |
| Washoe | ..... | 1,577.30 | 118.51 | 2.78 | ..... | ..... | 1,698.59 |
| White Pine | 33.67 | 119.48 | 35,666.67 | 122.13 | 3.05 | ..... | 35,945.00 |
| | 17,139.89 | [a] 351,420.33 | 56,880.78 | 3,046.56 | 29.60 | 387.05 | 428,904.21 |

[a] Includes 232,699.56 ounces from gold ore, 2,681.38 ounces from gold and silver ore, and 116,039.39 ounces from silver ore.

## SILVER.

The mine production of silver in Nevada in 1916 was 13,837,525 ounces, valued at $9,105,092, a decrease of 622,315 ounces in quantity but an increase of $1,773,953 in value, as compared with the output of 1915. Nye County was again the largest producer, with 8,868,267 ounces, against 10,220,018 ounces in 1915; and Churchill County produced 1,386,524 ounces in 1916, against 1,620,573 ounces in 1915. The largest producer of silver was the Belmont mine, at Tonopah, in Nye County, followed by the Tonopah Extension, the Tonopah Mining Co., and the Jim Butler property. Milling plants using amalgamation and cyanidation in the extraction of the precious metals produced 11,326,955 ounces of silver, of which 25,094 ounces were recovered by amalgamation and 11,301,861 ounces by cyanidation. Nye County was credited with the largest production of silver

by cyanidation—8,133,969 ounces—from ores treated principally in the Tonopah district. In Churchill County, 1,343,032 ounces of silver were recovered by cyanidation. Concentrates from milling plants yielded 1,107,119 ounces of silver, against 859,587 ounces in 1915. The dry or siliceous ores milled produced 759,370 ounces from concentrates in 1916, against 646,303 ounces in 1915. Lead concentrates contained 133,837 ounces of silver, or an average per ton of 26.53 ounces, against 107,276 ounces, or an average per ton of 39.89 ounces in 1915. Zinc concentrates contained 114,220 ounces, or an average per ton of 5.37 ounces, and the lead-zinc concentrates contained 500 ounces, or 12.50 ounces per ton.

*Mine production of silver in Nevada in 1916, in fine ounces.*

| County. | Placers. | Deep mines. | | | | | | Total. |
|---|---|---|---|---|---|---|---|---|
| | | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | |
| Churchill | | 1,386,044 | 32 | 76 | | 372 | | 1,386,524 |
| Clark | | 244,217 | 5,052 | 33,746 | 21,520 | 695 | 99,558 | 404,788 |
| Douglas | | | 38 | | | | | 38 |
| Elko | 1 | 170,517 | 44,952 | 15,275 | | 37,411 | | 268,156 |
| Esmeralda | | 61,942 | 93,644 | 15,091 | | | | 170,677 |
| Eureka | 44 | 36,392 | 6,034 | 101,137 | 79 | | | 143,686 |
| Humboldt | 90 | 859,811 | 2,467 | 6,979 | | 77 | | 869,424 |
| Lander | 1,050 | 135,108 | 3,817 | 70,564 | | | | 210,539 |
| Lincoln | | 359,278 | 58,524 | 61,473 | | 852 | 78,918 | 559,045 |
| Lyon | 40 | 34,755 | 1,285 | | | | | 36,080 |
| Mineral | 11 | 314,023 | 51,190 | 65,844 | | 62 | | 431,130 |
| Nye | 4,501 | 8,857,517 | 701 | 5,548 | | | | 8,868,267 |
| Ormsby | | 468 | 16 | | | | | 484 |
| Storey | | 285,827 | | | | | | 285,827 |
| Washoe | | 2,405 | 7,213 | 46,132 | | | | 55,750 |
| White Pine | 7 | 3,607 | 109,428 | 22,720 | 14 | 11,334 | | 147,110 |
| | 5,744 | [a] 12,751,911 | 384,393 | 444,585 | 21,613 | 50,803 | 178,476 | 13,837,525 |

[a] Includes 705,970 ounces from gold ore, 82,496 ounces from gold and silver ore, and 11,963,445 ounces from silver ore.

## COPPER.

Ores mined and treated in 1916 contained 105,116,813 pounds of copper, valued at $25,858,736, an increase for the year of 36,480,443 pounds in quantity and of $13,847,371 in value. The Nevada Consolidated mines at Ely, in White Pine County, produced a large share of the State total, followed by the mines in the Yerington district of Lyon County. White Pine County mines produced 93,107,945 pounds in 1916, against 64,682,966 pounds in 1915; Lyon County mines, 3,491,390 pounds, against 700,874 pounds in 1915; Mineral County mines, 2,986,361 pounds, against 433,584 pounds; Elko County mines, 1,771,689 pounds, against 413,500 pounds; and Esmeralda County mines, 1,391,392 pounds, against 1,693,450 pounds. Concentrates recovered at milling plants contained 88,117,957 pounds of copper, against 62,997,281 pounds in 1915. Of the output in 1916, copper concentrates contained 88,077,620 pounds, against 62,992,883 pounds in 1915. Crude ore shipped to smelters contained 16,764,814 pounds of copper, against 5,611,836 pounds in 1915. The crude copper ores smelted contained 16,364,531 pounds, of which 1,415,021 pounds were produced from sulphide ores and

14,949,510 pounds from oxidized ores. Lead ores of smelting grade produced 139,341 pounds of copper—42,631 pounds from sulphide ores and 96,710 pounds from oxidized ores. Copper-lead ores shipped contained 200,213 pounds of copper, of which the oxidized ores contained 158,613 pounds and the sulphide ores 41,600 pounds.

*Mine production of copper in Nevada in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Total. |
|---|---|---|---|---|---|---|
| Churchill | 1,113 | 2,036 | ..... | ..... | 6,460 | 9,609 |
| Clark | 3,618 | 565,248 | 245 | ..... | 3,977 | 573,088 |
| Douglas | ..... | 5,981 | ..... | ..... | ..... | 5,981 |
| Elko | 207 | 1,629,007 | 7,228 | ..... | 135,247 | 1,771,689 |
| Esmeralda | 69,908 | 1,292,378 | 29,106 | ..... | ..... | 1,391,392 |
| Eureka | 19,331 | 42,931 | 16,804 | ..... | ..... | 79,066 |
| Humboldt | 1,615 | 132,987 | 169 | ..... | 409 | 135,180 |
| Lander | 1,034 | 566,360 | 8,599 | ..... | ..... | 576,493 |
| Lincoln | 58,901 | 663,024 | 76,066 | 4,941 | 4,006 | 806,938 |
| Lyon | ..... | 3,491,390 | ..... | ..... | ..... | 3,491,390 |
| Mineral | 6,109 | 2,980,032 | 64 | ..... | 156 | 2,986,361 |
| Nye | 1,550 | 4,256 | 217 | ..... | ..... | 6,023 |
| Ormsby | ..... | 134 | ..... | ..... | ..... | 134 |
| Storey | 903 | ..... | ..... | ..... | ..... | 903 |
| Washoe | ..... | 174,621 | ..... | ..... | ..... | 174,621 |
| White Pine | 2,897 | 93,048,625 | 6,465 | ..... | 49,958 | 93,107,945 |
| | [a] 167,186 | 104,599,510 | 144,963 | 4,941 | 200,213 | 105,116,813 |

[a] Includes 94,608 pounds from gold ore, 2,955 pounds from gold and silver ore, and 69,623 pounds from silver ore.

## LEAD.

The mine production of lead in Nevada in 1916 was 25,637,278 pounds, valued at $1,768,972, against 16,637,277 pounds, valued at $781,952 in 1915, an increase in 1916 of 9,000,001 pounds in quantity and of $987,020 in value. Lincoln County mines continued to have the largest output, 10,356,926 pounds, in 1916, followed by Clark County mines, with 8,405,796 pounds, and by Eureka County mines, with 2,804,971 pounds. More than 24 per cent of the output of lead was derived from concentrates and nearly 75 per cent from crude ores shipped directly to smelters. Lead concentrates (carbonates and sulphides) shipped to smelters from the milling plants of the State contained 4,983,673 pounds, against 2,264,706 pounds in 1915, and averaged 49.40 per cent of lead in 1916, against 42.10 per cent in 1915. Zinc concentrates shipped in 1916 contained 1,191,119 pounds of lead and averaged 2.80 per cent. The total crude ore of shipping grade contained 19,189,934 pounds of lead, against 12,657,269 pounds in 1915. The iron-manganese ores, classified under dry or siliceous ores, contained 8,043,513 pounds of lead. Oxidized lead ore contained 5,711,549 pounds of lead, against 2,939,773 pounds in 1915. Zinc ores shipped produced 448,513 pounds of lead, all of which was from oxidized ores. Copper-lead ores of shipping grade produced 880,477 pounds of lead, of which 763,382 pounds were from oxidized carbonate ores and 117,095 pounds were from the sulphides. The oxidized lead-zinc ores shipped produced 182,218 pounds of lead, and sulphide lead-zinc ores shipped contained 1,440 pounds of lead.

*Mine production of lead in Nevada in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|
| Churchill | 4,734 | ..... | 556 | ..... | 3,612 | ..... | 8,902 |
| Clark | 4,956 | ..... | 3,987,991 | 443,775 | 32,958 | 3,986,116 | 8,405,796 |
| Elko | 314 | ..... | 412,156 | ..... | 686,441 | ..... | 1,098,911 |
| Esmeralda | 1,566 | ..... | 400,568 | ..... | ..... | 6,400 | 408,534 |
| Eureka | 36,171 | ..... | 2,766,920 | 1,890 | ..... | ..... | 2,804,981 |
| Humboldt | 2,651 | ..... | 71,602 | ..... | 1,481 | ..... | 75,734 |
| Lander | 12,284 | 598 | 186,157 | ..... | ..... | ..... | 199,039 |
| Lincoln | 7,943,267 | 59,077 | 2,241,132 | ..... | 8,169 | 105,281 | 10,356,926 |
| Mineral | 73,499 | ..... | 195,697 | ..... | 1,538 | ..... | 270,734 |
| Nye | 3,712 | ..... | 131,643 | ..... | ..... | ..... | 135,355 |
| Storey | 11,057 | ..... | ..... | ..... | ..... | ..... | 11,057 |
| Washoe | ..... | ..... | 220,243 | ..... | ..... | ..... | 220,243 |
| White Pine | 10,438 | ..... | 1,480,062 | 2,848 | 146,278 | 1,440 | 1,641,066 |
| | [a] 8,104,649 | 59,675 | 12,044,727 | 448,513 | 880,477 | 4,099,237 | 25,637,278 |

[a] Includes 42,745 pounds from gold ore, 15,232 pounds from gold and silver ore, and 8,046,672 pounds from silver ore.

## ZINC.

The mine production of recoverable zinc from zinc and lead-zinc ores mined in Nevada in 1916 is calculated at 32,443,189 pounds, valued at $4,347,387, against 24,376,450 pounds, valued at $3,022,680, in 1915. Clark County is credited with the largest part of the output, or 29,400,537 pounds of zinc, most of which came from the Yellowpine district. The remainder of the zinc output was from the Pioche district, in Lincoln County, and from Elko, Eureka, White Pine, and Esmeralda counties. Zinc concentrates amounted to 21,267 tons and averaged 28.57 per cent of zinc. Lead-zinc concentrates contained 25.05 per cent of zinc per ton, against 28.85 per cent in 1915. The shipments of zinc ore to the smelters amounted to 31,886 tons and consisted of 31,835 tons of carbonate and silicate ores and 51 tons of sulphide ore. The zinc ore shipped averaged 31.19 per cent of zinc and the lead-zinc ore 24.69 per cent.

*Mine production of recoverable zinc in Nevada in 1916, in dry pounds.*

| County. | Zinc ore. | Lead-zinc ore. | Total. |
|---|---|---|---|
| Clark | 18,870,455 | 10,530,082 | 29,400,537 |
| Elko | 963,438 | ..... | 963,438 |
| Esmeralda | ..... | 17,680 | 17,680 |
| Eureka | 34,935 | ..... | 34,935 |
| Lincoln | ..... | 2,002,105 | 2,002,105 |
| White Pine | 19,989 | 4,505 | 24,494 |
| | 19,888,817 | 12,554,372 | 32,443,189 |

*Zinc-producing ores and concentrates from Nevada mines sold in 1916.*

| Classification. | County. | Quantity. | Average zinc assay of ore and concentrate.[a] |
|---|---|---|---|
| | | *Short tons.* | *Per cent.* |
| Sulphide zinc ore | Eureka | 51 | 24.07 |
| Sulphide lead-zinc ore | White Pine | 9 | 30.09 |
| Oxidized zinc ore | Clark, Elko, Eureka, and White Pine | 31,835 | 36.71 |
| Oxidized lead-zinc ore | Clark and Esmeralda | 768 | 29.04 |
| Zinc concentrates | Lincoln and Clark | 21,267 | 33.60 |
| Lead-zinc concentrates | Clark | 40 | 30.00 |
| | | 53,970 | 35.36 |

[a] Actual assay content.

## MINING INDUSTRY.

All parts of Nevada showed activity during 1916 in mining and prospecting for metals, but especially those districts where silver, copper, lead, quicksilver, tungsten, antimony, and zinc ores are found. In the Mason Valley district, the mines were preparing for a large production, anticipating the opening of the copper smelter at Thompson early in 1917. There was considerable activity in copper properties around Luning, and some of the old silver properties on the Comstock Lode were said to be opening new ore. Manhattan district may again become an important gold producer. Recent work in the White Caps, Big Pine, Big Four, and other mines has been encouraging, but development in the White Caps mine was of particular interest. A sampling works was built at Jean to handle Goodsprings ore.

Ores of various kinds were milled at 84 plants, against 92 plants in 1915. Most of these were operated for short periods each year. Twenty-seven plants used the amalgamation process, against 38 in 1915; 6, both amalgamation and concentration, against 4 in 1915; 3, amalgamation and cyanidation, against 5 in 1915. Fifteen plants, against 12 in 1915, used concentration, of which 4 were equipped with the oil flotation process, and 1 was equipped for oil flotation only. Thirty-one straight cyanidation mills were operated in 1916, against 27 in 1915; and 2 mills used cyanidation and concentration, against 5 in 1915. Two plants, in Lyon County, were doing experimental work with the leaching process.

During 1916 there were 2,111 pounds of quicksilver consumed at amalgamation mills, and 2,320,323 pounds of potassium and sodium cyanide at cyanidation mills, a consumption of 0.034 pound of mercury per ounce of gold and silver bullion produced and of 0.016 pound of mercury per ton of ore treated; the consumption of cyanide was 0.20 pound per ounce of gold and silver bullion produced and 1.70 pounds per ton of ore and tailings treated.

The total value of bullion recovered from ore and tailings was $14,295,539, against $15,441,468 in 1915.

*Gold and silver produced from Nevada mills in 1916.*

| County. | Ore. | Bullion recovered from ore by— | | | | Total value. |
|---|---|---|---|---|---|---|
| | | Amalgamation. | | Cyanidation. | | |
| | | Gold. | Silver. | Gold. | Silver. | |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | |
| Churchill | [a] 110,787 | | | 13,176.62 | 1,343,032 | $1,156,100 |
| Clark | 30,079 | 2,708.93 | 1,160 | [b] 10,334.87 | [b] 235,756 | 425,530 |
| Elko | 26,894 | 1,957.90 | 2,838 | [c] 11,402.16 | [c] 153,093 | 378,780 |
| Esmeralda | [d] 341,127 | 432.88 | 128 | [e] 106,802.01 | [e] 45,125 | 2,246,518 |
| Eureka | 15,000 | | | 2,709.68 | 24,327 | 72,021 |
| Humboldt | [f] 106,634 | 8,968.92 | 7,814 | [g] 4,669.94 | [g] 808,968 | 819,383 |
| Lander | 3,266 | 1,248.53 | 515 | [h] 104.78 | [h] 18,907 | 40,755 |
| Lincoln | 10 | | | 6.15 | 15 | 137 |
| Lyon | 4,572 | 1,953.33 | 1,640 | [i] 1,706.41 | [i] 26,201 | 93,973 |
| Mineral | [j] 196,574 | 155.93 | 85 | [k] 32,636.89 | [k] 244,236 | 838,651 |
| Nye | [l] 532,304 | 15,775.94 | 8,056 | [m] 90,659.76 | [m] 8,133,969 | 7,557,673 |
| Ormsby | 5 | 3.89 | 1 | [n] 12.00 | [n] 467 | 636 |
| Storey | [o] 55,656 | 2,686.56 | 2,196 | [p] 19,386.23 | [p] 267,660 | 633,850 |
| Washoe | [q] 1,174 | 1,445.25 | 569 | 17.21 | 105 | 30,675 |
| White Pine | 53 | 38.49 | 92 | | | 857 |
| | 1,424,135 | 37,376.55 | 25,094 | 293,624.71 | 11,301,861 | 14,295,539 |

[a] Also yielded 215 tons of concentrates.
[b] Includes bullion from 600 tons of old tailings.
[c] Includes bullion from 1,000 tons of old tailings.
[d] Also yielded 2 tons of concentrates.
[e] Includes bullion from 1,979 tons of old tailings.
[f] Also yielded 898 tons of concentrates.
[g] Includes bullion from 725 tons of old tailings.
[h] Includes bullion from 5,000 tons of old tailings.
[i] Includes bullion from 6,942 tons of old tailings.
[j] Also yielded 9 tons of concentrates.
[k] Includes bullion from 45,103 tons of old tailings.
[l] Also yielded 1,412 tons of concentrates.
[m] Includes bullion from 6,337 tons of old tailings.
[n] Includes bullion from 100 tons of old tailings.
[o] Also yielded 111 tons of concentrates.
[p] Includes bullion from 7,219 tons of old tailings.
[q] Also yielded 9 tons of concentrates.

Mills equipped for the concentration of low-grade ore treated 4,066,727 tons, or more than 68 per cent of the total ore sold or treated. The concentrates produced aggregated 561,950 tons and contained $1,001,747 in gold, 1,107,119 ounces of silver, 88,117,957 pounds of copper, 6,204,542 pounds of lead, and 12,170,681 pounds of recoverable zinc, valued in all at $25,466,232, or a total average value per ton of $45.32.

*Mine production of gold, silver, copper, lead, and zinc from Nevada concentrates in 1916.*

**By counties.**

| County. | Ore to concentrating mills. | Concentrates. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value of concentrates. |
|---|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Churchill | | 215 | 241.12 | 35,943 | 1,113 | | | $28,908 |
| Clark | 35,849 | 22,533 | 144.00 | 118,559 | 451 | 5,642,907 | 10,168,576 | 1,833,050 |
| Elko | | 1 | 15.73 | 42 | 157 | 17 | | 393 |
| Esmeralda | 16,627 | 817 | 1,429.80 | 2,869 | 30,970 | | | 39,064 |
| Humboldt | 20 | 900 | 4,796.26 | 14,219 | | 78 | | 108,508 |
| Lander | 1,720 | 30 | .92 | 4,414 | 185 | 493 | | 3,002 |
| Lincoln | 10,108 | 3,299 | 387.05 | 78,918 | 4,941 | 105,281 | 2,002,105 | 336,690 |
| Mineral | | 9 | 16.85 | 5 | 224 | 60 | | 410 |
| Nye | 25,000 | 1,854 | 5,713.99 | 690,248 | 1,550 | 3,712 | | 572,939 |
| Storey | 189 | 223 | 1,179.14 | 13,212 | 903 | 11,057 | | 34,054 |
| Washoe | 3,161 | 325 | 41.74 | 45,088 | | 215,065 | | 45,371 |
| White Pine | 3,974,053 | 531,744 | 34,492.93 | 103,602 | 88,077,463 | 225,872 | | 22,463,843 |
| | 4,066,727 | 561,950 | 48,459.53 | 1,107,119 | 88,117,957 | 6,204,542 | 12,170,681 | 25,466,232 |

**By kinds of concentrates.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dry or siliceous | 4,024 | 13,235.26 | 759,370 | 34,310 | 5,215 | | $782,062 |
| Copper | 531,573 | 34,482.46 | 99,152 | 88,077,620 | 17 | | 22,445,154 |
| Lead | 5,044 | 430.81 | 133,837 | 4,030 | 4,983,673 | | 441,835 |
| Zinc | 21,267 | 291.00 | 114,220 | 1,546 | 1,191,119 | 12,150,281 | 1,791,877 |
| Copper-lead | 2 | 20.00 | 40 | 451 | 518 | | 586 |
| Lead-zinc | 40 | | 500 | | 24,000 | 20,400 | 4,718 |

*Mine production of gold, silver, copper, lead, and zinc from Nevada crude ore shipped to smelters in 1916.*

**By counties.**

| County. | Quantity. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Churchill | 156 | 316.41 | 7,549 | 8,496 | 8,902 | ..... | $14,212 |
| Clark | 36,846 | 1,724.86 | 49,313 | 572,637 | 2,762,889 | 19,231,961 | 2,976,695 |
| Douglas | 84 | .05 | 38 | 5,981 | ..... | ..... | 1,497 |
| Elko | 12,450 | 264.36 | 111,248 | 1,769,311 | 1,041,222 | 963,438 | 714,862 |
| Esmeralda | 29,411 | 20,853.15 | 122,179 | 1,321,484 | 408,534 | 17,680 | 867,110 |
| Eureka | 6,507 | 2,205.92 | 117,986 | 59,735 | 2,785,271 | 34,935 | 334,796 |
| Humboldt | 2,250 | 481.19 | 38,085 | 135,180 | 66,400 | ..... | 72,843 |
| Lander | 4,443 | 932.65 | 183,981 | 425,677 | 198,546 | ..... | 258,757 |
| Lincoln | 151,631 | 1,256.80 | 478,530 | 789,362 | 10,229,138 | ..... | 1,240,847 |
| Lyon | 19,908 | 173.40 | 8,199 | 3,491,390 | ..... | ..... | 867,861 |
| Mineral | 23,948 | 1,436.44 | 178,557 | 2,979,252 | 175,082 | ..... | 892,161 |
| Nye | 751 | 382.28 | 29,014 | 4,473 | 131,643 | ..... | 37,176 |
| Ormsby | 2 | .56 | 16 | 134 | ..... | ..... | 55 |
| Storey | 123 | 119.82 | 2,759 | ..... | ..... | ..... | 4,292 |
| Washoe | 726 | 194.38 | 9,988 | 174,621 | 5,178 | ..... | 53,903 |
| White Pine | 81,817 | 1,370.36 | 42,850 | 5,027,081 | 1,377,129 | 24,494 | 1,391,489 |
| | 371,053 | 31,712.63 | 1,380,292 | 16,764,814 | 19,189,934 | 20,272,508 | 9,728,556 |
| **By kinds of ore.** | | | | | | | |
| Dry or siliceous | 144,666 | 6,328.52 | 655,557 | 60,729 | 8,043,513 | ..... | $1,132,119 |
| Copper | 171,702 | 22,371.04 | 283,507 | 16,364,531 | 59,675 | ..... | 4,678,792 |
| Lead | 19,176 | 2,983.49 | 367,451 | 139,341 | 9,574,098 | ..... | 998,348 |
| Zinc | 31,886 | ..... | 21,613 | ..... | 448,513 | 19,888,817 | 2,710,269 |
| Copper-lead | 2,846 | 29.58 | 50,803 | 200,213 | 880,477 | ..... | 144,045 |
| Lead-zinc | 777 | ..... | 1,361 | ..... | 183,658 | 383,691 | 64,983 |

## PRODUCTION BY COUNTIES.

The following tables show the State output, by counties, in 1916, the production of each metal, and the total value; also the production of ore, the average value per ton, by counties, in 1915 and 1916, and the statistics of placer mines. The tables are followed by a review of the mining industry for each county and each producing mining district.

*Mine production of gold, silver, copper, lead, and zinc in Nevada in 1916.*

| County. | Gold. | | | | | Silver. | |
|---|---|---|---|---|---|---|---|
| | Placers. | | Deep mines. | | Total value. | Quantity. | Value. |
| | Quantity. | Value. | Quantity. | Value. | | | |
| | *Fine ounces.* | | *Fine ounces.* | | | *Fine ounces.* | |
| Churchill | ..... | ..... | 13,734.15 | $283,910 | $283,910 | 1,386,524 | $912,333 |
| Clark | ..... | ..... | 14,912.66 | 308,272 | 308,272 | 404,788 | 266,351 |
| Douglas | 4.26 | $88 | .05 | 1 | 89 | 38 | 25 |
| Elko | 2.32 | 48 | 13,646.88 | 282,106 | 282,154 | 268,156 | 176,447 |
| Esmeralda | ..... | ..... | 129,871.78 | 2,684,688 | 2,684,688 | 170,677 | 112,305 |
| Eureka | 501.79 | 10,373 | 5,049.33 | 104,379 | 114,752 | 143,686 | 94,545 |
| Humboldt | 347.04 | 7,174 | 18,917.38 | 391,057 | 398,231 | 869,424 | 572,081 |
| Lander | 7,435.14 | 153,698 | 2,329.88 | 48,163 | 201,861 | 210,539 | 138,535 |
| Lincoln | ..... | ..... | 1,659.50 | 34,305 | 34,305 | 559,045 | 367,852 |
| Lyon | 112.62 | 2,328 | 3,833.14 | 79,238 | 81,566 | 36,080 | 23,740 |
| Mineral | 35.94 | 743 | 34,264.64 | 708,313 | 709,056 | 431,130 | 283,683 |
| Nye | 8,667.11 | 179,165 | 112,546.81 | 2,326,549 | 2,505,714 | 8,868,267 | 5,835,320 |
| Ormsby | ..... | ..... | 16.45 | 340 | 340 | 484 | 318 |
| Storey | ..... | ..... | 23,371.75 | 483,137 | 483,137 | 285,827 | 188,074 |
| Washoe | ..... | ..... | 1,698.59 | 35,113 | 35,113 | 55,750 | 36,684 |
| White Pine | 33.67 | 696 | 35,911.33 | 742,353 | 743,049 | 147,110 | 96,799 |
| | 17,139.89 | 354,313 | 411,764.32 | 8,511,924 | 8,866,237 | 13,837,525 | 9,105,092 |

*Mine production of gold, silver, copper, lead, and zinc in Nevada in 1916*—Con.

| County. | Copper. | | Lead. | | Recoverable zinc content. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Churchill | 9,609 | $2,364 | 8,902 | $614 | ..... | ..... | $1,199,221 |
| Clark | 573,088 | 140,980 | 8,405,796 | 580,000 | 29,400,537 | $3,939,672 | 5,235,275 |
| Douglas | 5,981 | 1,471 | ..... | ..... | ..... | ..... | 1,585 |
| Elko | 1,771,689 | 435,836 | 1,098,911 | 75,825 | 963,438 | 129,101 | 1,099,363 |
| Esmeralda | 1,391,392 | 342,252 | 408,534 | 28,189 | 17,680 | 2,369 | 3,169,833 |
| Eureka | 79,066 | 19,450 | 2,804,981 | 193,544 | 34,935 | 4,681 | 426,972 |
| Humboldt | 135,180 | 33,254 | 75,734 | 5,226 | ..... | ..... | 1,008,792 |
| Lander | 576,493 | 141,817 | 199,039 | 13,734 | ..... | ..... | 495,947 |
| Lincoln | 806,938 | 198,507 | 10,356,926 | 714,628 | 2,002,105 | 268,282 | 1,583,574 |
| Lyon | 3,491,390 | 858,882 | ..... | ..... | ..... | ..... | 964,188 |
| Mineral | 2,986,361 | 734,645 | 270,734 | 18,680 | ..... | ..... | 1,746,064 |
| Nye | 6,023 | 1,482 | 135,355 | 9,339 | ..... | ..... | 8,351,855 |
| Ormsby | 134 | 33 | ..... | ..... | ..... | ..... | 691 |
| Storey | 903 | 222 | 11,057 | 763 | ..... | ..... | 672,196 |
| Washoe | 174,621 | 42,957 | 220,243 | 15,197 | ..... | ..... | 129,951 |
| White Pine | 93,107,945 | 22,904,554 | 1,641,066 | 113,233 | 24,494 | 3,282 | 23,860,917 |
| | 105,116,813 | 25,858,736 | 25,637,278 | 1,768,972 | 32,443,189 | 4,347,387 | 49,946,424 |

*Production from deep mines in Nevada in 1915 and 1916.*

| County. | Ore sold or treated. | | Number of deep mines producing. | | Average value per ton.[a] | | Average value per ton in gold and silver.[a] | |
|---|---|---|---|---|---|---|---|---|
| | 1916 | Increase or decrease. | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 |
| | *Short tons.* | *Short tons.* | | | | | | |
| Churchill | 110,943 | − 13,048 | 13 | 20 | $8.97 | $10.81 | $8.94 | $10.78 |
| Clark | 103,374 | + 50,577 | 54 | 85 | 59.33 | 50.64 | 4.72 | 5.56 |
| Douglas | 84 | − 62 | 3 | 3 | 13.68 | 17.82 | 7.43 | .31 |
| Elko | 40,729 | + 20,854 | 75 | 75 | 17.68 | 26.99 | 9.07 | 11.25 |
| Esmeralda | 389,351 | − 80,842 | 70 | 59 | 10.89 | 8.14 | 10.25 | 7.18 |
| Eureka | 22,082 | − 87,238 | 38 | 30 | 4.49 | 18.86 | 3.84 | 9.01 |
| Humboldt | 109,683 | + 53,000 | 96 | 84 | 20.99 | 9.13 | 20.75 | 8.78 |
| Lander | 16,099 | − 1,601 | 23 | 30 | 5.35 | 21.22 | 5.08 | 11.55 |
| Lincoln | 162,153 | + 32,001 | 19 | 23 | 7.73 | 9.77 | 2.09 | 2.48 |
| Lyon | 31,422 | + 14,652 | 41 | 44 | 12.91 | 30.61 | 5.60 | 3.28 |
| Mineral | 266,183 | + 74,927 | 93 | 93 | 5.12 | 6.56 | 4.67 | 3.73 |
| Nye | 564,450 | − 66,537 | 72 | 73 | 12.58 | 14.47 | 12.57 | 14.45 |
| Ormsby | 107 | − 400 | 4 | 3 | 6.46 | 6.46 | 3.98 | 6.15 |
| Storey | 63,187 | − 21,957 | 23 | 24 | 4.45 | 10.64 | 4.44 | 10.62 |
| Washoe | 5,061 | − 57 | 22 | 28 | 11.65 | 25.68 | 9.55 | 14.19 |
| White Pine | 4,056,257 | +848,276 | 50 | 40 | 3.76 | 5.88 | .21 | .21 |
| | 5,941,165 | +822,545 | 696 | 714 | 6.67 | 8.35 | 3.58 | 2.96 |

[a] Value per ton, placer product excluded.

*Production from placer mines in Nevada in 1915 and 1916.*

| County. | 1915 | | | | | 1916 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mines. | | Gold. | Silver. | Total value. | Mines. | | Gold. | Silver. | Total value. |
| | Hydraulic. | Drift. | | | | Hydraulic. | Drift. | | | |
| | | | | *Fine ounces.* | | | | | *Fine ounces.* | |
| Douglas | 2 | ..... | $1,378 | 10 | $1,383 | 2 | ..... | $88 | ..... | $88 |
| Elko | 3 | ..... | 364 | 8 | 368 | 1 | ..... | 48 | 1 | 49 |
| Esmeralda | 1 | ..... | 85 | 2 | 86 | ..... | ..... | ..... | ..... | ..... |
| Eureka | 8 | ..... | 9,298 | 40 | 9,318 | 6 | ..... | 10,373 | 44 | 10,402 |
| Humboldt | 12 | 1 | 8,836 | 113 | 8,893 | 6 | 5 | 7,174 | 90 | 7,233 |
| Lander | 12 | 7 | 160,766 | 1,189 | 161,369 | 1 | 10 | 153,698 | 1,050 | 154,389 |
| Lyon | 1 | ..... | 165 | 2 | 166 | 3 | ..... | 2,328 | 40 | 2,354 |
| Mineral | 5 | ..... | 7,128 | 181 | 7,220 | 2 | 1 | 743 | 11 | 750 |
| Nye | 32 | 15 | 204,744 | 4,462 | 207,006 | 24 | 3 | 179,165 | 4,501 | 182,127 |
| Washoe | 3 | ..... | 160 | 2 | 161 | ..... | ..... | ..... | ..... | ..... |
| White Pine | 1 | ..... | 2,395 | 21 | 2,406 | 1 | ..... | 696 | 7 | 701 |
| | 80 | 23 | 395,319 | 6,030 | 398,376 | 46 | 19 | 354,313 | 5,744 | 358,093 |

## CHURCHILL COUNTY.

There were 110,943 tons of ore mined in 1916 by 20 producers, against an output of 123,991 tons mined by 13 producers in 1915. The total average value per ton increased from $8.97 in 1915 to $10.81 in 1916. This value for both years was practically that of gold and silver, as only a small quantity of ore containing copper and lead was shipped. The larger part of the output was of milling grade and yielded gold and silver bullion at cyanidation plants. There was also some concentrate containing gold, silver, and a little copper produced at one of the plants. This was shipped directly to the smelters, as was also 156 tons of crude ore containing gold and silver, with some copper and lead.

*Eagleville district.*—The output of one property amounted to 36 tons containing principally gold.

*Fairview district.*—Nine reports from deep-mine operators show the production of 52,688 tons of ore. The greater part of this output was from the Nevada Hills property, on which was operated the 150-ton cyanide mill, which is equipped also for table concentration. The total value of the district output amounted to $327,913. In 1915 the total value was $306,152.

The mine production in 1916 of the Nevada Hills property[1] netted the company $89,351 from the cyanidation of 52,436 tons of ore and the shipment of 215 tons of concentrate. The value of gold and silver in the bullion and concentrate, which also contained a little copper, was $325,719.53, or an average of $6.21 per ton. The tailing loss amounted to $77,113.76, or $1.47 per ton. The mining cost of 52,436 tons of ore was $1.038 per ton, and the milling cost, $2.673 per ton. The following extract is taken from the annual report of the company:

> Ore treated during the year was not discovered as a result of mine development but rather was the low-grade material contained in and near the outcrop of the Nevada Hills vein, which automatically became profitable with

[1] Nevada Hills Mining Co. Seventh Ann. Rept., for year ending Dec. 31, 1916.

the higher silver prices that prevailed. This favorable condition may not be expected to apply to the walls of the previously worked stopes in other parts of the mine.

At present the remaining production area is so limited that only with difficulty can the necessary tonnage be obtained for the continuous operation of the mill. * * *

Approximately 260,000 tons are stored upon the tailing dump. The mill record value is gold 0.007 ounce and silver 2.3 ounces. So far the experimental work that has been conducted indicates no process that could profitably handle the material as a whole, and, since oxidation is so seldom of benefit to silver ores, it is not considered likely that further exposure will render them more amenable to cyanidation.

During the coming year an effort will be made to re-treat some of the higher grade tailing that was discharged during the early operation of the property, but as the greater part of the expense connected with such work consists of chemicals that are now obtainable only at abnormal prices, the profit to be expected from this source, even at present value of silver, seems uncertain or small.

*Holy Cross district.*—The Silver Star, Pyramid Fraction, and four other properties produced an output valued at $1,522 in gold, silver, copper, and lead.

*Wonder district.*—The district output consists largely of the production of one mine, the Nevada Wonder. During the period from October 1, 1915, to December 31, 1916, this property[1] produced 72,241 tons of ore yielding 10,933 ounces of gold and 1,243,753 ounces of silver, valued in all at $1,031,243.43, or an average value per ton of $14.27. The report of the company gives the following paragraphs:

The following table gives a comparison of costs of mining operations for the preceding fiscal year and this fiscal period:

| | 1915 | 1916 |
|---|---|---|
| Direct cost per ton of ore hoisted | $3.33 | $4.46 |
| Indirect cost per ton of ore hoisted | .83 | .83 |
| Total operating cost per ton of ore hoisted | 4.16 | 5.29 |
| Total operating cost per ton of ore and waste hoisted | 3.26 | 3.69 |
| Total operating cost per ton of ore and waste broken | 3.13 | 3.38 |
| Transportation of ore to mill per ton of ore hoisted | .035 | .04 |
| Average cost per foot of drifting, crosscutting, raising, and winze-sinking | 7.70 | 9.31 |

This table shows an increase of $1.13 per ton in the total mining cost for 1916 over the preceding fiscal year. The difference in the cost of development work per ton of ore is $0.47 over 1915, due to a greater footage of development work having been done, and to the higher cost per foot, as explained elsewhere. This leaves a balance of $0.66 between the direct mining costs of these two periods, and this is due to increased costs of practically all supplies, increased cost of labor, and a greater amount of supplies, especially timber, required to mine the ground safely on account of the width of the stopes in some places, and to the treacherous hanging wall in other places.

[1] Nevada Wonder Mining Co. Tenth Ann. Rept., for year ending Dec. 31, 1916.

The following table shows the combined costs of the Nevada Wonder Mining Co. and the Churchill Milling Co., and the profits per ton of ore mined and milled, as compared with those of the two previous years:

| | 1914 | 1915 | 1916 |
|---|---|---|---|
| Mining cost per ton of ore, including transportation | $4.70 | $4.19 | $5.33 |
| Milling cost per ton of ore | 3.37 | 2.81 | 3.31 |
| Marketing cost per ton of ore | .28 | .27 | .26 |
| Total cost per ton | 8.35 | 7.27 | 8.90 |
| Average value per ton of ore | 15.52 | 13.97 | 15.40 |
| Loss in tailings per ton of ore | 1.06 | .82 | 1.13 |
| Recovery per ton | 14.46 | 13.15 | 14.27 |
| Less total cost per ton | 8.35 | 7.27 | 8.90 |
| Profit per ton of ore mined and milled | 6.11 | 5.88 | 5.37 |

## CLARK COUNTY.

*Mine production in Clark County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 54 | 52,797 | $167,639 | 160,749 | 301,327 | 4,655,985 | 21,061,182 | $3,132,290 |
| 1916 | 85 | 103,374 | 308,272 | 404,788 | 573,088 | 8,405,796 | 29,400,537 | 5,235,275 |
| Increase, 1916 | | 50,577 | 140,633 | 244,039 | 271,761 | 3,749,811 | 8,339,355 | 2,102,985 |

Eighty-five mines in the county were credited with a production in 1916 of 103,374 tons of ore, which was 50,577 tons more than was produced by 54 mines in 1915. The total average value per ton decreased from $59.33 in 1915 to $50.64 in 1916, and the gold and silver value per ton in this ore increased from $4.72 to $5.56. Of the total ore, 36,846 tons were shipped directly to the smelters and produced $35,656 in gold, 49,313 ounces of silver, 572,637 pounds of copper, 2,762,889 pounds of lead, and 19,231,961 pounds of recoverable zinc, valued at $2,976,665, or an average value per ton of $80.79. There were 35,849 tons of ore treated by concentration or separation processes, which produced lead concentrates, zinc concentrates, and a small quantity of lead-zinc and copper-lead concentrates. The 22,533 tons of concentrates produced contained $2,977 in gold, 118,559 ounces of silver, 451 pounds of copper, 5,642,907 pounds of lead, and 10,168,576 pounds of recoverable zinc, valued in all at $1,833,050, or at an average per ton of $81.35. At gold and silver mills, 30,079 tons of ore were treated and produced $269,639 in gold and 236,916 ounces of silver.

*Eldorado Canyon district.*—Nine producers reported the output of 24,868 tons of ore, which contained $213,132 in gold, 241,789 ounces of silver, 1,205 pounds of copper, 11,771 pounds of lead, valued in all at $373,338, or an average value per ton of $15.01. The larger part, or 24,786 tons, was treated in amalgamation and cyanidation mills, some of which were equipped with concentration tables. Only 24 tons of concentrate, containing gold, silver, and a little lead, was shipped to the smelters with 82 tons of ore containing

the same metals. The Techaticup mine was the principal producer of milling ore treated by cyanidation. This property is opened by an incline shaft 600 feet deep and has 5,000 feet of drifts. The Flagstaff property, operated by the Colorado Nevada Co., yielded gold and silver from ore treated by cyanidation. This property has a 600-foot shaft and 2,000 feet of drifts. The Rand property has a 10-stamp amalgamation and concentration mill, which produced bullion and a small quantity of concentrates containing lead. Other producing properties were the Silver Legion, Golden Empire, Lucky Jim, and Skylark.

*Gas Peak district.*—This district, situated 16 miles northwest of Las Vegas, became important during 1916 through the operation of the June Bug property, which yielded a considerable quantity of oxidized zinc ore contaiing some lead and silver.

*Gold Butte district.*—The Tramp and two prospects in the district produced copper ore carrying little or no silver. The ore produced in this district is hauled by wagon about 15 miles to the branch line of the Salt Lake Route which has its terminal near St. Thomas.

*Searchlight district.*—Fifteen producers reported 6,322 tons of ore in 1916. The ore contained $80,677 in gold, 4,340 ounces of silver, 24,392 pounds of copper, and 9,951 pounds of lead, valued in all at $90,220, or an average value per ton of $14.27. In 1915 the total output of 7,766 tons had an average value per ton of $14.19. Of this ore 5,283 tons were treated at gold and silver mills, nearly all of which used the amalgamation process. At one plant there was some concentrate saved which contained a small quantity of copper and lead. There were also 429 tons of ore shipped directly to the smelters which contained principally gold and silver, with a little copper and lead. In addition to the production from ore, bullion was recovered from the treatment of 600 tons of old tailings by cyanidation. The Duplex property yielded the largest quantity of ore, but in point of value the Quartette yielded the greatest quantity of bullion. Both of these properties were operated by a number of lessees. The ores from the Blossom mine were treated in a neighboring mill, yielding gold and silver bullion. At the Big Casino property a small quantity of ore was treated in a concentration plant, yielding a concentrate containing gold and silver with a little lead and copper. The Peerless group yielded milling ore and a small quantity of ore of shipping grade. Lessees operated the mill on ore from the Spokane group.

*Sunset district.*—From the Lucy Gray property a small quantity of bullion was shipped in 1916.

*Yellowpine district.*—Reports received from 54 producers gave an aggregate output of 71,155 tons of ore in 1916, as against a production of 38,391 tons reported by 35 producers in 1915. In 1916 the ore contained $14,333 in gold, 156,492 ounces of silver, 494,604 pounds of copper, 8,349,850 pounds of lead, and 28,889,282 pounds of recoverable zinc, valued in all at $4,686,281, or an average value per ton of $65.86. The ore produced in 1915 was valued at $2,926,300, or an average value per ton of $76.22. The output of the mines in 1916 was divided almost equally between milling ore and ores of shipping grade. There were 35,839 tons of ore milled, which yielded 22,507 tons of concentrate containing 115,902 ounces of silver, 5,639,405 pounds of lead, and 10,168,576 pounds of recoverable zinc. These concentrates had a total value of $1,827,972, or an average value per

ton of $81.22. The ore shipped directly to the smelters amounted to 35,316 tons, containing 693.36 ounces of gold, 40,590 ounces of silver, 494,604 pounds of copper, 2,710,445 pounds of lead, and 18,720,706 pounds of recoverable zinc, valued in all at $2,858,309, or an average value per ton of $80.93. A few of the mines are equipped with dry concentration mills, but most of the concentrates produced were the output of one concentrating plant, the property of the Yellow Pine Co. at Goodsprings. This property[1] during 1916 produced 22,661.7 tons of ore at an average cost of $3.81 per ton. Of the quantity mined, 2,081 tons were shipped directly to the smelters and 20,580.7 tons were milled. From the ore going into the mill, which averaged 4.53 ounces of silver, 10.5 per cent of lead, and 30.4 per cent of zinc, there were shipped 2,294 tons of lead concentrate, containing per ton 20.2 ounces of silver, 54.2 per cent of lead, and 13.2 per cent of zinc; 14,240 tons of zinc concentrate, assaying 2.27 ounces of silver, 4.48 per cent of lead, and 32.22 per cent of zinc; and 3,571 tons of zinc slimes, assaying 3.6 ounces of silver, 6.5 per cent of lead, and 33.5 per cent of zinc. Crude zinc ore, 2,081 tons, containing 3.42 ounces of silver, 6.25 per cent of lead, and 37.6 per cent of zinc, was also shipped. Dividends disbursed in 1916 amounted to $800,000. A short article[2] on the Yellow Pine mill was published in August from which the following extract is taken:

From the mill bin the ore is fed to a short conveyor, on which the larger pieces of waste are sorted out. This conveyor dumps over a 1-inch grizzly and the oversize goes to an 8-inch by 16-inch roll-jaw crusher. Grizzly and rock breaker both discharge to a chain elevator, which dumps to the fine-ore bin.

The fine ore is delivered by a shaking feeder to a set of 16-inch by 36-inch Cornish rolls set to one-fourth inch. These discharge to a wet elevator, which raises the ore to the top of the mill, where it passes successively over ¼-inch and ½-inch impact screens. The screen oversize is treated on two 2-compartment Harz jigs, which make lead concentrates from the bed and hutch of the first compartment and middlings through the second compartment and over the tail-board. The middlings from the coarse jig are returned to the first set of rolls and those from the finer jig to a second set, both of which discharge to the elevator and to the impact screens.

The undersize of the second screen goes to a 5-compartment Richard's classifier, which makes six products, each of which goes to an Overstrom table. The tables make only two products, lead and zinc concentrates. The lead goes to tubs and the zinc, with all slime, to settling bins beneath the table floor. The lead is shoveled to small cars, the zinc is drawn off through gates and the slime overflows to ponds, from which it is shoveled out and shipped when a sufficient amount accumulates.

Under this system an extended run of 16,136.3 tons of crude ore assaying 10.2 per cent lead, 31.8 per cent zinc, and 5.4 ounces silver produced 1,521.085 tons of lead concentrate averaging 53.2 per cent lead, 13.75 per cent zinc, and 28.1 ounces silver; 11,260.65 tons of zinc concentrate assaying 33.2 per cent zinc, 4.4 per cent lead, and 2.5 ounces silver; and 2,173.0 tons of slime averaging 7.3 per cent lead, 35.1 per cent zinc, and 4.0 ounces of silver; and 833.4 tons of waste was removed by sorting. During 1915 milling cost was $1.53 per ton.

Two new Stebbins dry concentrating mills were erected at the Sultan and Christmas zinc-lead properties. The Boss mine yielded monthly 250 tons of copper-gold-platinum ore, and the company is completing the first unit of a chloridizing-leaching plant to treat daily 10 tons of ore averaging 4 per cent of copper, 1 ounce of gold, 2 ounces of silver, and 1.5 ounces of platinum and palladium. Ore

[1] Yellow Pine Mining Co. Ann. Rept. for year ending Dec. 31, 1916.
[2] Met. and Chem. Eng., Aug. 15, 1916, p. 205.

similar to this was found in the Oro Amigo property, adjoining the Boss.

The Anchor mill is characteristic of several dry mills in the district and uses a Stebbins table for concentration. The mill was described in a recent article[1] as follows:

The ore is fed from the bin over a 1-inch grizzly to an 8-inch by 12-inch Dodge crusher set to three-fourths inch. The grizzly and crusher product go to a set of 14-inch by 30-inch rolls set to one-eighth inch. The roll product is elevated to an 8-foot trommel with 8-mesh ton-cap screen, the oversize of which returns to the rolls and the undersize goes without further classification to a No. 6 Stebbins table with a capacity of 2 tons per hour.

There are three products from this table: Dust, which is removed by a fan and stacked behind the mill, lead concentrate, and either zinc concentrate or tailing, according to whether a zinc-lead or a lead ore is being treated. The lead concentrate is run to a bin by a conveyor belt, and a screw removes the tailing or zinc product to another bin to be loaded to cars and wasted or shipped, as the case may be.

The Stebbins table is made in seven different sizes, the extreme capacity of the largest size being 12 tons per hour. In general design and principles of action it is similar to the standard makes of riffle-deck water tables. The shape of the deck is similar to that of the Wilfley and is provided with longitudinal riffles, all of which extend clear to the concentrate end.

The deck is of sheet metal with perforated slots which have a slanting lip over each so as to direct the air current through the ore layer at an angle instead of directly upward. Beneath the deck is an air chamber into which a blower forces air at a pressure varied to suit conditions and from which it escapes through the slots in the deck. The table has a reciprocating motion and stratifies the ore as on a water table, simply using air as a medium instead of water.

All machinery—crusher, trommel, rolls, elevator, and table—is tightly housed and the dust is drawn off by a 30-inch fan. While this ameliorates conditions, the mill is at best very dusty and employees wear respirators.

By this system a lead-zinc ore carrying 35 per cent lead and 24 per cent zinc is separated into a lead concentrate, assaying 67 per cent, and a zinc concentrate, carrying 34 per cent zinc and 6 per cent lead.

On a straight lead ore the saving approximates 65 per cent. This saving appears low, but it should be borne in mind that at this mill the dust, which has about the same metal content as the original ore, is not treated, and the process is comparable with a wet mill that does not treat its slimes.

## DOUGLAS COUNTY.

Three producers reported the output of 84 tons of ore, all of which was shipped directly to the smelter. The total value per ton of the ore was $17.82 and the gold and silver value per ton was $0.31. The placer production amounted to $88 in gold.

*Buckskin district.*—The Minnesota-Nevada property yielded a small quantity of copper ore in 1916.

*Gardnerville district.*—In the Silver Lake region, the California Bank mine, and the Copper King mine in the Genoa section, produced ores containing a little copper and silver.

*Mount Siegel district.*—A very small production of gold bullion was reported in 1916 from the Ancient Gold placer property.

[1] Met. and Chem. Eng., Aug. 15, 1916, p. 204.

## ELKO COUNTY.

*Mine production in Elko County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 78 | 19,875 | $147,468 | 65,307 | 413,500 | 436,848 | 631,819 | $351,819 |
| 1916 | 76 | 40,729 | 282,154 | 268,156 | 1,771,689 | 1,098,911 | 963,438 | 1,099,363 |
| Increase, 1916 | | 20,854 | 134,686 | 202,849 | 1,358,189 | 662,063 | 331,619 | 747,544 |

[a] Includes placer production.

The output of ore reported by 75 deep-mine producers was 40,729 tons in 1916, which is 20,854 tons more than was produced by the same number of producers in 1915. The total average value per ton of the ore increased from $17.68 in 1915 to $26.99 in 1916, and the gold and silver value per ton from $9.07 to $11.25. More than half of the ore (26,894 tons) was treated at gold and silver mills, and yielded bullion containing $276,177 in gold and 155,931 ounces of silver. A small quantity of gold and silver concentrate was produced at one of the mills also. The ore shipped was 12,450 tons, containing gold, silver, copper, lead, and zinc, valued at $714,862, or an average value per ton of $57.42. Some old tailings and slag were re-treated or shipped, and $48 in gold and 1 ounce of silver were reported from placers in 1916.

*Alder district.*—About 8 miles north of Gold Creek, the operations on the Clipper property resulted in the production of a small quantity of ore.

*Aura district.*—Lessees shipped a small quantity of ore from one property, and some bullion was recovered from the ore of another property in the district. One placer producer reported a small production.

*Centennial district.*—Ore mined from the Richelieu property resulted in the output of a small quantity of bullion. There were also a few thousand pounds of ore containing a little lead and silver shipped from the Red Cloud property.

*Contact district.*—Thirteen producers reported the production of 3,327 tons of ore, all of which was of shipping grade and contained $2,314 in gold, 14,852 ounces of silver, 688,564 pounds of copper, and 3,295 pounds of lead, valued in all at $181,701, or an average value per ton of $54.61. The output in 1915 consisted of only 36 tons of ore, which had an average value per ton of $65.16. The most important shipments were from the Delano property. The Mammoth, Bonanza, Palo Alto, and Hanks properties were also producers.

*Delker district.*—Considerable crude ore carrying copper only was shipped from the Delker property.

*Divide district.*—This district, 8 miles northwest of Tuscarora at the head of Dry Creek, was actively prospected in 1916, and some ore carrying principally silver and some gold was reported shipped from the San Juan group of claims.

*Ferber district.*—A small quantity of copper ore was shipped from the Sydney property to a smelter near Salt Lake.

*Gold Circle district.*—For a number of years the district mines have regularly produced small quantities of gold and silver bullion, but they became unusually active in 1916 when the Elko Prince cyanide mill was completed so that ores from the property of the same name and others in the district could be milled, thereby allowing the owners and lessees a fair margin of profit. Altogether there was mined in the district 23,947 tons of ore, which yielded $243,665 in gold and 157,207 ounces of silver, valued in all at $347,107, or an average value per ton of $14.49. Only 21 tons of gold and silver ore were shipped directly to the smelter. In 1915 ten operators produced 2,946 tons of ore, of which 1 ton was shipped directly to the smelter.

Next in importance to the Elko Prince is the Missing Link property. Some ore was also milled from the Hardscrabble and Esperanza properties.

*Jarbidge district.*—In 1916 the output of ore mined decreased about one-third from the output in 1915. Eight operators reported in 1916 the mining of 3,908 tons of ore, which yielded $31,845 in gold and 1,728 ounces of silver, valued in all at $32,982, or an average value per ton of $8.44. The Bluster was the largest producer of gold bullion, followed by the Flaxie, Long Hike, and Alpha properties. These used either the cyanidation or the amalgamation process in the reduction of the ores. From the old tailing dump of the Alpha property about 1,000 tons of tailings were re-treated by cyanidation.

The district is 70 miles from the railroad at Rogerson, Idaho, on the Oregon Short Line, and 100 miles from Twin Falls, Idaho. About 200 men are employed in the district. Much development has been performed on the Starlight, Jarbidge Gold, and Flaxie properties.

*Lone Mountain district.*—The Stewart Mining Co. had an option on the Lone Mountain property, from which lead-silver ore was produced, containing gold and a little copper. The Copper Queen property was also a producer, yielding copper ore containing a little silver.

*Merrimac district.*—The Pacific Consolidated property yielded a few tons of copper ore carrying gold, silver, and lead.

*Railroad district.*—Thirteen producers reported the shipment of 5,640 tons of ore made directly to the smelter, containing $1,259 in gold, 66,917 ounces of silver, 1,012,535 pounds of copper, and 706,419 pounds of lead, valued in all at $343,117, or an average value per ton of $60.84. In 1915, 2,210 tons of ore were produced having an average value per ton of $40.71. The Bunker Hill property was the principal producer, followed by the Lee, Ennor, Sweepstake, Sylvania, and Copper Bell properties. On the Bunker Hill property there were a number of lessees operating. The property is opened by the main crosscut adit 2,400 feet long, and yields an oxidized copper ore and a copper-lead ore.

*Spruce Mountain district.*—Ore from the Keystone, Ada H., and Black Forest properties was shipped directly to the smelters. The last-named property was the largest producer, yielding lead sulphide ore and some oxidized copper ore. The total output of the district amounted to 288 tons of ore, valued at $13,426, or an average value per ton of $46.62.

*Tecoma district.*—Six producers reported the output of 850 tons of ore, containing $267 in gold, 5,506 ounces of silver, 5,311 pounds of copper, and 246,243 pounds of lead, valued in all at $22,188. The output of the Delano and Cunapah properties was included in this district. Some lead ore was mined and some slag, containing lead, silver, copper, and gold, was shipped from the old smelter dumps.

*Tuscarora district.*—Very little activity in the way of production was reported from the district in 1916. Only 76 tons of ore, valued at $4,253, were shipped.

*Warm Creek district.*—The Polar Star property, operated by the Nevada Zinc Co., yielded considerable zinc ore.

## ESMERALDA COUNTY.

*Mine production in Esmeralda County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 71 | 470,193 | $4,689,260 | 253,180 | 1,693,450 | 107,219 | ..... | $5,119,015 |
| 1916 | 59 | 389,351 | 2,684,688 | 170,677 | 1,391,392 | 408,534 | 17,680 | 3,169,823 |
| Increase or decrease, 1916 | ..... | −80,842 | −2,004,572 | −82,503 | −302,058 | +301,315 | +17,680 | −1,949,192 |

Altogether 389,351 tons of ore were mined, of which 341,127 tons, treated by cyanidation or amalgamation, yielded $2,216,742 in gold and 45,253 ounces of silver, or an average value per ton of $6.59. There were 16,627 tons of ore treated at milling plants, yielding concentrates containing gold, silver, and copper. These concentrates, with 29,411 tons of crude ore, were shipped to the smelters. The crude ore contained $431,073 in gold, 122,179 ounces of silver, 1,321,484 pounds of copper, 408,534 pounds of lead, and 17,680 pounds of zinc, valued in all at $867,110, or an average value per ton of $29.48. There was no placer production reported in 1916.

*Basalt district.*—The reports of three producers show an output of a small quantity of lead, and some copper ore carrying silver.

*Goldfield district.*—A decided decrease in the gold output was reported for the year 1916.

*Mine production of Goldfield district, Nev., 1904–1916.*

| Year. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|
| | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 418,935 | $4,389,385 | 165,306 | 1,679,423 | ..... | $4,767,094 |
| 1916 | 383,456 | 2,651,158 | 129,781 | 1,317,400 | 2,418 | 3,060,801 |
| Increase or decrease, 1916 | −35,479 | −1,738,227 | −35,525 | −362,023 | +2,418 | −1,706,293 |
| Total, 1904–1916 | ..... | 78,352,095 | 1,128,529 | 6,136,603 | 26,080 | 80,083,392 |

Sixteen producers in 1916 reported an output of ore whose average value per ton was $7.98. The average value of the ore produced in 1915 was $11.38. The larger part of the output in 1916, or 338,991 tons, was milled at cyanidation plants and yielded 105,951.33 ounces of gold and 32,712 ounces of silver. Ore of shipping grade aggregated 27,631 tons and contained 20,518.21 ounces of gold, 93,840 ounces of silver, 1,247,492 pounds of copper, and 2,418 pounds of lead. At concentration mills, 16,627 tons of ore yielded 815 tons of concentrates containing 1,426.25 ounces of gold, 2,853 ounces of silver, and 30,970 pounds of copper. These totals include the output of the Goldfield Consolidated, Jumbo Extension, Florence, Atlanta, Great Bend, and smaller outputs made by lessees on various properties. The Florence property was put into the hands of a receiver November 23, after having added an oil flotation unit to its plant. The company expects to have the mill operating again as soon as the indebtedness is settled.

After many tests covering a long period, flotation on a large scale is to be introduced at the Goldfield Consolidated mill. It is reported that the company will be protected against litigation in the use of the flotation patents. Throughout the district ore is said to have been found of sufficient value to yield a profit. Operations of the Goldfield Consolidated have continued along normal lines, but with a production less than in past years owing to the gradual exhaustion of the richer ores found on upper levels and in oxidized zones. With the opening of deeper levels, making available a large tonnage of copper-bearing ore, the product became more difficult to treat by the cyanidation process in use, and the operators adopted a policy of mining and treating all the low-grade free-milling ore that could be handled at low cost and reserved the more refractory product for future treatment by flotation. The first unit of the plant designed to treat 500 tons of ore daily was to be ready in January, 1917.

The Goldfield Consolidated mines[1] produced in 1916 a total of 338,680 tons of ore, all of which was of milling grade averaging in gold and silver $7.52, and having a total value of $2,548,425.83. The recovery was $6.52 per ton, or a total of $2,211,348. The following table is taken from the annual report of the company:

*Production of Goldfield Consolidated Mines Co., 1916.*

| | Production (short tons). | Total value (and deductions). | Average per ton. | Per cent of total value. |
|---|---|---|---|---|
| Tons milled | 338,680 | $2,548,425.83 | $7.52 | ..... |
| Loss in tailings and smelter discount | ..... | 337,077.65 | .99 | ..... |
| Value recovered | ..... | 2,211,348.18 | 6.53 | 86.77 |
| Cost of ore purchased and amount paid lessees | ..... | 3,832.71 | .01 | ..... |
| Value realized | ..... | 2,207,515.47 | 6.52 | 86.62 |
| Net costs | ..... | 1,754,781.42 | 5.18 | ..... |
| Net realization from operation | ..... | 452,734.05 | 1.34 | 17.76 |
| Expenditures, account exploration and development | ..... | 24,114.21 | .07 | ..... |
| Net realization | ..... | 428,619.84 | 1.27 | 16.82 |

[1] Goldfield Consolidated Mines Co. Tenth Ann. Rept., for year ending Dec. 31, 1916.

*Production of Goldfield Consolidated Mines Co.*—Continued.

| Shafts. | Milling ore. | | |
|---|---|---|---|
| | Short tons. | Average value. | Total value. |
| Mohawk | 175,237 | $7.64 | $1,339,121.69 |
| Combination | 43,491 | 9.98 | 433,040.41 |
| Jumbo | 6,792 | 5.74 | 38,957.27 |
| Laguna | 80,823 | 8.30 | 670,969.38 |
| Jumbo No. 2 | 257 | 2.06 | 528.30 |
| Dumps | 6,296 | 2.10 | 13,244.49 |
| Combination tailings | 24,836 | 1.81 | 44,879.10 |
| Ores purchased | 257 | 10.91 | 2,803.98 |
| Lessees | 691 | 7.06 | 4,881.21 |
| | 338,680 | 7.53 | 2,548,425.83 |

Of the total production, 306,600 tons were produced from company underground operations; 691 tons were produced by lessees, and 31,132 tons were recovered from dumps. * * *

Your company's milling plant has operated satisfactorily throughout the year and has averaged 928 tons per day. An average recovery of 86.77 per cent was made. Compared with last year, costs of milling concentrate treatment show an increase of 23 cents per ton accounted for by the following: Reduced tonnage with a consequent increase in cost of labor; increased cost of all supplies.

Certain sections of the ground owned by the Goldfield Consolidated Co. are to be opened to lessees and the "split check" system will be adopted. Under this plan the company furnishes machine drills, sharp steel, tools, timber, track, rails, and all supplies except powder to the lessees free of charge, and in addition hoists the ore after it has been delivered to the company. A deduction of $4 per ton will be made from all grades of ore to cover the expense of transportation, sampling, and milling. Ninety per cent of the gold value, based on gold at $20 per ounce, will be figured as the net recovery of the ore. From this recovered value the deduction of $4 per ton will be made and the remaining profit will be divided with the lessee. This form of lease will apply to the portion of the company's estate from which ore will be hoisted through the working shafts of the company. On outlying portions of the company's estate and all portions not connected with any of the main workings of the company a similar but slightly modified form will apply.

*Gold Mountain district.*—Five producers reported the output of 148 tons of ore, containing $1,186 in gold, 2,182 ounces of silver, 2,086 pounds of copper, and 97,282 pounds of lead, valued in all at $9,847, or an average value per ton of $66.53. All of this ore was of shipping grade.

*Hornsilver district.*—Producers reported from seven properties an output of 1,418 tons of ore, 520 tons of which were shipped directly to the smelter and 898 tons yielded gold and silver bullion at a custom cyanide plant near Tonopah. The total ore output contained $15,042 in gold, 19,541 ounces of silver, 2,408 pounds of copper, 6,676 pounds of lead, and 17,680 pounds of recoverable zinc, valued in all at $31,322, or an average value per ton of $22.09. The Orleans property was the principal producer, and yielded gold and silver bullion and shipping ore of good grade, which was forwarded directly to the smelters.

*Lida district.*—The Calumet and Syncline properties were the principal producers, and yielded copper ore containing gold but no silver.

*Lone Mountain district.*—Eleven producers reported the output of 847 tons of ore, containing $541 in gold, 14,337 ounces of silver, 29,784 pounds of copper, and 245,802 pounds of lead, valued in all at $34,262. All of this ore was of shipping grade and came principally from the General Thomas, Alpine, Sunset, Great Seal, and Tetrahedrite properties.

*Montezuma district.*—The Monitor and Montezuma claims produced a few tons of ore shipped directly to the smelters in 1916.

*Palmetto district.*—In 1916 the Montana Smuggler property, equipped with a 2-stamp amalgamation mill, yielded milling ore from which some concentrate and bullion were produced.

*Silverpeak district.*—After the closing of the Pittsburg-Silverpeak property in October, 1915, a few lessees treated ore intermittently during 1916. Some tailings were also treated on company account.

## EUREKA COUNTY.

*Mine production in Eureka County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 46 | 109,320 | $334,047 | 186,583 | 15,813 | 1,299,085 | 61,053 | $500,040 |
| 1916 | 36 | 22,082 | 114,752 | 143,686 | 79,066 | 2,804,981 | 34,935 | 426,972 |
| Increase or decrease, 1916 | ..... | −87,238 | −219,295 | −42,897 | +63,253 | +1,505,896 | −26,118 | −73,068 |

Ore produced in 1916 by 30 operators aggregated 22,082 tons, which is 87,238 tons less than was produced by 38 operators in 1915. The total average value per ton increased from $4.49 in 1915 to $18.86 in 1916, and the gold and silver value in this ore from $3.84 to $9.01 per ton. Of the ore, 15,000 tons were treated at gold and silver mills and yielded bullion containing $56,014 in gold and 24,327 ounces of silver, which had an average total value of $4.80 per ton. There were 6,507 tons shipped directly to smelters, containing $45,601 in gold, 117,986 ounces of silver, 59,735 pounds of copper, 2,785,271 pounds of lead, and 34,935 pounds of zinc, valued in all at $334,796, or an average value per ton of $51.45. Placer bullion reported from six sources amounted to $10,373 in gold and 44 ounces of silver. The closing of the Buckhorn property in Mill Canyon district caused the largest part of the 1916 decrease in the county total, amounting to $73,068.

*Antelope district.*—Shipments from the Patriot group contained principally lead and silver. While doing annual assessment work about 20 tons of dump ore were shipped.

*Eureka district.*—Nineteen producers reported the production of 3,666 tons of shipping ore containing $38,731 in gold, 80,657 ounces of silver, 41,420 pounds of copper, 1,290,448 pounds of lead, and 20,870 pounds of recoverable zinc, valued in all at $193,829, or an average value per ton of $52.87. In 1915 there were 1,135 tons of

ore produced, having an average value per ton of $52.39. The principal production came from the California & Silver King property. There were smaller shipments made from the Connelly, Diamond, Distinction, Jackson, Mohawk, Bullwhacker, Lucia Tuffa, Phoenix Silver, Richmond Eureka, Silver Lick, and Alkali properties.

*Lynn district.*—Production from one deep mine and six placers was $19,398 in gold and 63 ounces of silver. The placers were the Compromise No. 10 and Golder Doll, Mephisto, Bulldog No. 1 and No. 2, Hilltop, and Deep Snow. This bullion averages about 0.930 fine. The Lynn Big Six Mining & Milling Co. shipped ore ranging from 1 to 7 ounces of gold per ton, while doing development work. The latter part of the year a 30-ton amalgamation mill was constructed.

*Maggie Creek district.*—The Little Marsh property was a producer of copper ore containing a little gold and silver.

*Mill Canyon (Buckhorn) district.*—Some bullion was recovered from a clean-up of the Buckhorn property. Work ceased in January, 1916.

*Mineral Hill district.*—The largest producer in the district in 1916 was the Union Mines Co. The Buster and the Mineral Hill Consolidated also produced some ore. The total output of the district aggregated 3,042 tons of ore, containing gold, silver, copper, lead, and zinc valued at $128,800, or an average value per ton of $42.34. In 1915 there were 1,547 tons produced with an average value per ton of $39.18.

## HUMBOLDT COUNTY.

*Mine production in Humboldt County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 109 | 56,683 | $809,343 | 740,560 | 51,362 | 101,088 | $1,198,546 |
| 1916 | 95 | 109,683 | 398,231 | 869,424 | 135,180 | 75,734 | 1,008,792 |
| Increase or decrease, 1916 | | +53,000 | −411,112 | +128,864 | +83,818 | −25,354 | −189,754 |

[a] Includes placer production.

The output of ore in Humboldt County in 1916 was reported by 84 producers, against 96 producers in 1915. The total average value per ton decreased from $20.99 in 1915 to $9.13 in 1916. This value was practically all for gold and silver. Milling plants using principally the cyanidation process treated 106,634 tons of ore, which yielded $281,940 in gold and 816,782 ounces of silver, having an average value per ton of $7.68. Some gold and silver concentrate was also produced at the milling plants, which, with a small production of concentrate containing gold, silver, and a little lead, was shipped to smelters. Ore of shipping grade aggregated 2,250 tons and contained $9,947 in gold, 38,085 ounces of silver, 135,180 pounds of copper, and 66,400 pounds of lead, valued in all at $72,843, or an average value per ton of $32.37. There was also a small output from old

tailings and slag. The placer output reported from 11 sources amounted to $7,174 in gold and 90 ounces of silver, as against $8,836 in gold and 113 ounces of silver in 1915.

*Antelope district.*—The Antelope Springs property, besides shipping some antimony, also produced lead-silver ore, which was shipped directly to the smelter. The Haystack, Jackson Mountain, and Bonanza Mountain properties were also producers.

*Dun Glen district.*—The Black Hole property was operated during the year and yielded some ore from which bullion was extracted by amalgamation. Five other properties had small outputs. The total output of the district for gold, silver, lead, and a little copper was $4,924.

*Echo district.*—The La Toska property yielded a few tons of silver ore containing gold.

*Golconda district.*—The Oro Belle property was the only producer in the district and yielded a small quantity of silver ore.

*Gold Run district.*—Twelve producers of ore reported the output of 1,751 tons of ore, containing $1,257 in gold, 4,901 ounces of silver, 107,941 pounds of copper, and 22,313 pounds of lead, valued in all at $32,576, or an average value per ton of $18.60. Of this ore 600 tons yielded gold and silver bullion and the remainder was shipped directly to the smelters. In 1915 the total ouptut of 12 producers aggregated 763 tons, which had an average value per ton of $16.02. Most of the ore produced was copper ore running from 4 to 11 per cent from the Caroline property. The Adelaide, Honolulu, Silver Shield, and Gold Ledge were also producers. The last-named property treated its ore in a 20-stamp amalgamation mill, yielding some bullion. The plant was closed pending the erection of a cyanide mill, as tests proved that that process was better suited to the ore.

*Imlay district.*—Producers reporting from 8 deep and 1 placer properties shipped 95 tons of ore carrying gold, silver, copper, and lead and having a total value of $4,810.

*National district.*—The National Mines Co. operated its 10-stamp amalgamation and concentration mill during 1916, producing considerable bullion and concentrate containing gold and silver. There was also a small shipment of bullion from a neighboring property, which is equipped with a small mill.

*New Goldfields district.*—The Cotton Tail group of claims, situated near the head of Dry Gulch between Rebel Creek and Spring Canyon, was operated during the year and produced a few tons of gold ore.

*Red Butte district.*—The Volcano, Solo, and Metallic properties yielded some copper ore during the year. These properties are situated about 15 miles due north of Antelope, a station on the Western Pacific Railroad.

*Rochester district.*—Reports received from 11 deep mines and 5 placer producers gave an aggregate production of $81,228 in gold, 816,620 ounces of silver, 22,046 pounds of lead, and 268 pounds of copper, valued in all at $620,151. The greater part of the ore (67,423 tons) was treated by the cyanide process, and 569 tons were shipped directly to the smelter. In 1915 the output of 20 deep mines and 5 placers was valued at $443,091. As in former years, the Rochester Mines Co. was the largest producer, followed by the Nevada Packard. There was also considerable bullion shipped from the Lincoln Hill property, which is equipped with an amalgamation mill. Among

the other producers were the Buck & Charley, Humboldt Queen, and Silver Bell properties.

Placer operators reported the production of $1,430 in gold and 11 ounces of silver. The properties having the greatest production were the Bonanza and Limerick. Smaller productions came from various other sources.

At the Rochester Mines Co. milling ore was treated by cyanidation. Extracts from a letter to the writer, dated July 2, 1917, follow:

> During the past year many changes, alterations, and additions have been made to the mine and mill equipment. The capacity of the mill has been increased from 110 tons to 180 tons per day. * * *
>
> A Leschen aerial tramway was constructed from the mine to the mill, a distance of about 2¼ miles, to facilitate the transportation of our ore. The aerial tramway was completed and put into operation on the 20th of April, 1917. * * * The tramway has a capacity of 30 tons per hour and works by gravity, using but very little electric power. * * *
>
> During the fiscal year we mined and milled 39,188 dry tons, gross value $1.02 gold and $9.39 silver per ton, or a total value of $10.41 per ton. * * *
>
> On the eighth level a short crosscut to the west discovered the Adams vein, which yields high values in gold and silver. Drifts have been advanced 200 feet on the ore and stoping is progressing. The north breast shows 8 feet of as fine ore as has ever been exposed in the mine. Native silver is generally present in the quartz. This vein has also been opened up on the seventh level, where drifts are being driven in ore to north and south. On the eighth level a winze begun on the Adams vein shows the ore going down maintaining its width and values.

*Rosebud district.*—Mines of this district continue to produce small quantities of ore, shipped to the railroad by lessees or owners of properties.

*Seven Troughs district.*—There were 8,089 tons of ore yielding gold bullion and concentrates, and 65 tons of gold and silver ore shipped directly to the smelter. At one of the mills 725 tons of tailing were re-treated. The value of the entire output, including some bullion recovered from surface workings, amounted to $167,854. In 1915 the total output of the district was valued at $476,535 from a total output of 8,038 tons of ore. The greater part of the production came from the Seven Troughs Coalition. The Fairview mine was also operated and produced bullion and shipping ore. This and the Delaware treated their ores at the Darby mill. Other producers were the Signal Peak, Monarch, and Annie.

*Sonoma Mountain district.*—The Wolverine Mining Co., situated in the Harmon or Sonoma mountains, 5 miles southeast of Winnemucca, shipped a few tons of silver ore containing a little copper and gold.

*Spring Valley district.*—Some gold and silver was reported from the operations of placers owned by the Federal Mining Co., and various smaller productions were contributed by transient miners. Altogether the output amounted to $2,909 in gold and 44 ounces of silver.

*Sunshine district.*—The Gem Five and Superlative properties were producers of gold and silver ore. The latter property is equipped with a 2-stamp mill, in which the operators are experimenting with amalgamation, concentration, and cyanidation.

*Trinity-Arabia district.*—A small quantity of old slag was shipped from a smelter dump, which, in the early days, accumulated from the operations of the Montezuma and other mines in the district. It carried silver, lead, and a small percentage of antimony.

*Unionville district.*—Small shipments of bullion were made from the Star Peak property and three other prospects in the district in 1916.

*Warm Springs district.*—The Ashdown mine yielded some gold and silver bullion from ore treated in an amalgamation mill.

*Winnemucca Mountain district.*—From the Rexall and Bonanza properties, operated by the Winnemucca Mountain Co., an important tonnage of ore was treated by the cyanidation process in a mill completed in 1916. This property is opened by a vertical shaft 200 feet deep and has 2,000 feet of drifts. Some bullion also was recovered from another property in the district, and several small shipments of gold and silver ore were made directly to the smelter.

## LANDER COUNTY.

In Lander county 30 producers reported the output of 16,099 tons of ore, 1,601 tons less than was reported by 23 producers in 1915. The total average value of the ore increased from $5.35 in 1915 to $21.22 in 1916. The larger part of this value was represented by the gold and silver content. At gold and silver mills 3,266 tons of ore yielded $27,975 in gold and 19,422 ounces of silver, an average value of $12.48 per ton. The ore of shipping grade amounted to 4,443 tons, containing $19,280 in gold, 183,981 ounces of silver, 425,677 pounds of copper, and 198,546 pounds of lead, valued in all at $258,757, or an average value of $58.28 per ton. The placer output reported by 11 operators was $153,698 in gold and 1,050 ounces of silver, against a production in 1915 by 19 operators of $160,766 in gold and 1,189 ounces of silver.

*Battle Mountain district.*—From 13 deep mines and 11 placers there was produced $159,068 in gold, 41,360 ounces of silver, 566,890 pounds of copper, and 87,166 pounds of lead, valued in all at $331,752. There were shipped to the smelter 2,584 tons of ore containing copper and lead, with gold and silver values, and 1,670 tons of tailings, containing gold, silver, and copper. Only 80 tons were treated at a gold and silver mill and yielded bullion. At the Copper Basin and Copper Canyon property considerable copper ore as well as some tailing was shipped; and shipments of lead ore were made from the Marion mine and of rich silver ore from the Gyneeah property. Lead ore carrying silver also came from the Golden Sceptre. Reports received from placer operators showed a production of $153,698 in gold and 1,050 ounces of silver. The Bannack property was worked about three months, during which a small quantity of gold was recovered. The Dahl placers produced the largest quantity, and smaller amounts of gold were taken from the Comet, Eagle Eye, Hawkeye, Marietta & Piute, Oversight, and Quintette properties.

*Cortez district.*—Four reports from producers gave a total output of gold, silver, copper, and lead, valued at $36,162. The Garrison property was the principal producer of shipping ore. Old tailings from the Cortez property were re-treated by cyanidation.

*Hilltop district.*—The output of the district aggregated 3,814 tons of ore containing gold, silver, copper, and lead, the principal part

of which came from the Gray Eagle and the Kimberly Consolidated properties.

*Lander district.*—Four operators produced 609 tons of ore, yielding $3,621 in gold, 68,776 ounces of silver, 5,131 pounds of lead, and 712 pounds of copper, valued in all at $49,405, or an average value per ton of $81.12. The Maysville property was the principal producer of ore, which was shipped directly to the smelter and contained gold and silver.

*Reese River (Austin) district.*—From the Austin Dakota and Manhattan properties a small quantity of ore was produced by lessees. The total value of the output, which contained principally silver, with a little gold and a small quantity of copper, was $2,473.

## LINCOLN COUNTY.

*Mine production in Lincoln County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 19 | 130,152 | $40,477 | 457,825 | 297,183 | 7,695,155 | 2,579,745 | $1,006,161 |
| 1916 | 23 | 162,153 | 34,305 | 559,045 | 806,938 | 10,356,926 | 2,002,105 | 1,583,574 |
| Increase or decrease, 1916 | ..... | +32,001 | −6,172 | +101,220 | +509,755 | +2,661,771 | −577,640 | +577,413 |

The ore reported in 1916 was produced by 23 operators, against 19 operators in 1915. The average value per ton increased from $7.73 to $9.77, and the gold and silver value from $2.09 to $2.48 per ton. The greater part of the ore, 151,631 tons, was of shipping grade and contained $25,980 in gold, 478,530 ounces of silver, 789,362 pounds of copper, and 10,229,138 pounds of lead, valued in all at $1,240,847, or an average value per ton of $8.18. Ore treated at gold and silver mills aggregated 10 tons and yielded bullion. At concentrating plants 10,108 tons of ore yielded 3,299 tons of concentrates containing $8,001 in gold, 78,918 ounces of silver, 4,941 pounds of copper, 105,281 pounds of lead, and 2,002,105 pounds of zinc, valued in all at $336,690, or an average value per ton of $102.05. No placer production was reported in 1916.

*Groom district.*—This district was organized in the fall of 1869. It joins the Tem-Piute district on the south. Considerable silver-lead ore was produced from the Groom mine. Shipments were made by auto trucks a distance of 60 miles to Indian Springs, a station on the Las Vegas and Tidewater Railroad. The property is opened by a vertical shaft 200 feet deep and has 550 feet of drifts.

*Jack Rabbit district.*—The most important producer was the property of the Uvada Copper Co., which shipped copper and lead ore to the smelters. Similar ore was also shipped from the Ida May and Centennial properties.

*Pioche district.*—Sixteen producers reported the mining of 149,398 tons of ore, containing $30,978 in gold, 457,069 ounces of silver, 19,680 pounds of copper, 8,553,674 pounds of lead, and 2,002,105 pounds of recoverable zinc, valued in all at $1,209,816, or an average

value per ton of $8.10. Most of this product was oxidized iron manganese ore, which had a fluxing value in addition to that of gold, silver, copper, and lead, which was not included in the total given above. Of the total output, the Prince Consolidated shipped 137,120 tons of ore, which contained an average of 30 per cent of iron and 12.5 per cent of manganese, aside from other valuable metals. The producer of next importance was the Consolidated Nevada Utah property. Other producers were the Hamburg, Highland Mary, Mendha, Volcano, and Poorman.

The Prince Consolidated Co. built and started the operation of its flotation plant on Bullionville and Dry Valley tailings the latter part of 1916. The plant was erected on the old Bullionville smelter site, situated about half a mile from the station of Panaca, Nev., on the Pioche branch of the Salt Lake Route. These tailings are from ores treated about 40 years ago, and most of them have been retreated by amalgamation and cyanidation. They are highly siliceous and entirely oxidized. The lead occurs entirely as a carbonate, and the silver practically all as a chloride. The best method found from a metallurgical standpoint is the artificial filming or sulphidizing of the lead carbonate with a sulphide film, followed by flotation. Some difficulty was found with the roots of weeds, which had grown between the tailing. Their separation from the tailing was found necessary, and further changes in the mill were contemplated as soon as equipment could be delivered, some time during the early part of 1917.

## LYON COUNTY.

The output of 31,422 tons of ore, reported by 44 producers in 1916, was 14,652 tons more than was reported by 41 producers in 1915. The total average value per ton increased from $12.91 in 1915 to $30.61, but the gold and silver value of the ore decreased from $5.60 to $3.28 per ton. There were 4,572 tons of ore and 6,942 tons of old tailings treated at amalgamation and cyanidation plants, yielding $75,654 in gold and 27,841 ounces of silver and having an average value per ton of $8.16. There were 19,908 tons of ore shipped to smelters, containing $3,584 in gold, 8,199 ounces of silver, and 3,491,390 pounds of copper, valued in all at $867,861, or an average value per ton of $43.59. The placer output reported by 3 operators amounted to $2,328 in gold and 40 ounces of silver.

*Ramsey district.*—From the Ramsey Comstock property 500 tons of old tailings were re-treated and yielded bullion containing principally gold with some silver. The property had an amalgamation mill, and a 15-ton cyanide plant was added in 1916.

*Silver City district.*—Numerous lessees worked on various mining properties in the district, and reports from 21 of these gave a production of $74,639 in gold and 27,481 ounces of silver. Among the properties producing ore from which bullion was recovered were the Silver City, Golden, Silver King, Well Emma, Umatilla, Oest, Old Wine, Mount Bullion, Heywood & Santiago, Laura Temple, Hard Luck, and Buckeye & Carson. The placer claims in Gold Canyon, 2 miles from the Silver City post office, were operated by Chinamen, who recovered a small quantity of gold by sluicing operations.

*Yerington district.*—The ore produced from 20 properties aggregated 19,820 tons, containing $670 in gold, 1,693 ounces of silver,

and 3,491,390 pounds of copper, valued in all at $860,666. From the Nevada-Douglas property, the principal output of copper was made, most of which was shipped to the smelters near Salt Lake City. The Empire Nevada was also an important shipper of ore. Among the smaller shippers were the Gallagher, Mohawk, Montana, Red Top, Snowstorm, and Yerington Consolidated.

The copper smelter at Thompson, idle since September, 1914, resumed operations of part of the plant on February 14, 1917. About 400 tons of ore daily were shipped from the Mason Valley mine, owned by the smelting company, and about 800 tons of custom ores were received daily at the smelting plant.

At Ludwig the copper leaching plant of the Nevada-Douglas Co. was completed. It is designed to treat 250 tons of ore per day at a cost of $1.25 to $1.50 per ton, and it is planned to have the plant in full operation in September, 1917.

## MINERAL COUNTY.

Ninety-three producers reported 266,183 tons of ore, or 74,927 tons more than was reported by the same number of producers in 1915. The total average value per ton increased from $5.12 in 1915 to $6.56 in 1916, and the value of the gold and silver in the ore decreased from $4.67 to $3.73. The larger part of the ore (196,574 tons) was treated at gold and silver mills and yielded $677,888 in gold and 244,321 ounces of silver, and a small quantity of concentrate containing gold, silver, copper, and lead. This bullion included the recoveries made from 45,103 tons of old tailings re-treated by cyanidation. There were 23,948 tons of crude ore shipped to smelters, which contained $29,694 in gold, 178,557 ounces of silver, 2,979,252 pounds of copper, and 175,082 pounds of lead, valued in all at $892,161, or an average value per ton of $37.25. The output reported from three placers amounted to $743 in gold and 11 ounces of silver, against $7,128 in gold and 181 ounces of silver in 1915.

*Aurora district.*—The principal producer of the district was the Aurora Consolidated Co. operating the Humboldt, South Republic, and Golden Fleece claims. There was also some old tailing retreated at the Sharp cyanide plant.

During 1916 the total production of the Aurora Consolidated[1] was valued at $501,041.14, resulting from the treatment of 173,270 tons of ore. The gross profit for 1916 was $71,005.69.

*Bell district.*—The Olympia mining camp is situated at the north end of the Cedar Range, 25 miles northeast of Mina. During 1916 considerable development work was performed on several properties. At the Royal George group of claims a shaft was sunk with the inclination of the vein at a dip of 43 degrees to the 150-foot level, where the vein turns off flatly, the shaft continuing on the same dip to a depth of 225 feet. There are also levels at 100, 150, and 200 feet. These claims were located in January, 1915. A recent article[2] contains the following interesting account of this new camp:

> The actual outcrop was found in only two places about 65 feet apart and assayed from $15 to $90 across an average width of about 7 feet, the assays running in the ratio of 1 ounce of gold to 1¼ ounces of silver. This vein was heavily capped to the southeast by Siebert lake beds,[3] which cover large

[1] Goldfield Consolidated Mines Co. Tenth Ann. Rept., for year ending Dec. 31, 1916.
[2] Siebert, F. J., Nevada's latest gold district: Min. and Sci. Press, Mar. 31, 1917, p. 449.
[3] Named by Spurr, U. S. Geol. Survey Prof. Paper 42, 1905.

stretches of the country below the elevation of the camp, 5,975 feet above sea level. Northwest the vein was covered by occasional patches of lake bed, soil wash, and laterite. * * * In so far as the vein-bearing formations are concerned, practically all of the surface is totally obscured either by lake beds, soil wash, laterite, or flows of later rhyolite and andesitic breccia. At one point on the strike of the vein and 930 feet southeast of the shaft, remnants of outcrops are found embedded in a hot-spring deposit that shows gold quite plentifully by panning.

Underground, four different rock-flows are found, all of which dip northeast at about 20°. The vein is a fissure crossing the oldest flow of rhyolite until the 150-foot level is reached, where in places andesitic breccia forms the footwall. Usually, however, the vein is wholly within the rhyolite and for some distance only a few feet of rhyolite intervenes between the footwall and the underlying andesitic breccia. The workings disclose a strong, well-defined normal fault striking north and south, and dipping east at an angle of 50°. This fault has had a remarkable effect upon the shape of the vein. * * *

The vein originally was calcitic, but has been entirely replaced by quartz, leaving only the form of the calcite crystals. The vein filling consists of solid white quartz and adularia with branching stringers into the soft wall rocks as the limits of the vein are reached. The average width of the vein is about 7 feet, and the average value about $23.50 in gold and silver. No evidence exists in the oxidized vein of any base metal other than a small amount of iron and manganese. The richest ore is chalky white, with no sign of mineralization. The gold is finely divided and evenly disseminated. It resembles the ore of the Gold Roads district in Arizona, while the inclosing rhyolite closely resembles the rhyolite at Jarbidge, Nev. It is coarse-grained with large quartz phenocrysts, has a greenish color, and is well leached near the vein, particularly on the hanging-wall side.

Extensive tests prove that the ore is readily amenable to cyanide treatment after being ground to 200-mesh. An extraction of 98.2 per cent was made by actual mill test after 6 to 8 hours' treatment. A mill of 70 tons daily capacity is now being completed and is expected to be in operation early in April, 1917. Water has been piped 6 miles from an elevation 1,500 feet higher than the mill, which is placed near the collar of the shaft, a low trestle connecting them.

The Capt. Fagan property in 1916 was the only producer of note in the district and shipped to the smelters some lead ore containing good values in gold and silver.

*Belleville or Columbus district.*—Eight producers reported the output of 41,561 tons of ore and old tailings. There were 39,431 tons of tailings and 2,130 tons of smelting ore. The total value of the output amounted to $172,219. The Belleville Tailing Association operated a 120-ton cyanide plant during the greater part of 1916. From the Lucky Hill property, silver ore containing lead and a little copper and gold was shipped directly to the smelter.

*Hawthorne district.*—In 1916 eight producers reported the output of 330 tons of crude ore shipped directly to the smelters and containing gold, silver, copper, and lead. There was also some copper slag shipped and 8 tons of ore yielding gold and silver bullion at a milling plant. The largest part of the output came from the Lucky Boy mine, operated by lessees. On Pamlico Hill, about 9 miles from Hawthorne, erosion material from rich quartz deposits was worked by placer methods and some gold recovered.

*Klondyke district.*—The A. B. C. D. property produced ore from which gold and silver bullion was recovered and crude ore containing gold, silver, lead, and a little copper was shipped to the smelters.

*Mount Grant district.*—A small production of ore and some tailing, which yielded gold and silver bullion, was recovered from the Mammoth property, which is equipped with a 2-stamp mill and 10-ton cyanide plant.

*Mountain View district.*—The Yerington Mountain Copper Co. operated almost continuously during 1916, and shipped considerable copper ore containing small amounts of gold and silver. There were four other small shipments from the same district.

*Pine Grove district.*—The Pittsburg-Dolores Co., owning the Rockland mine, operated its 75-ton plant throughout the year, treating the ores by cyanidation. There was also a production of bullion reported from the Wheeler Gold and Pine Grove properties.

During the 18 months of operation of the Pittsburg-Dolores mill[1] at Rockland, Nev., there was milled 23,326 tons of rock from the mine, 2,052 tons from dumps, and 1,890 tons of tailings, having a total value of about $230,370, the value being in the gold content of the ore. During that time the quantity of tailings discharged had an average value per ton of $0.814. The extraction was 90.4 per cent. The average cost of milling was $2.75, but in this connection it is well to note that the costs were reduced from $3.20 during the first six months to $2.28 during the last six months, notwithstanding continual increase in the price of supplies. This was brought about by mechanical improvements and metallurgical saving. It was also caused by the increase in the ratio of gold to silver in the ore, which enables us to make a better extraction and also materially decreases the period of treatment. Bullion is now worth $3.52 per ounce. In January, 1916, we were receiving only $2.15 per ounce. Only a small portion of the increase is caused by the present high value of silver.

The average ore milled per day was 49 tons. This was increased to 60 during last year. Assaying, office, and general expenses averaged 73 cents per ton. Supplies increased in cost from 12 per cent, for some minor items, to as high as 220 per cent during the period. The increase is estimated at 68 cents per ton for the period over the prices that prevailed when operations were started in the summer of 1915.

At present two sets of rolls are used and, the treatment of a larger tonnage with satisfactory results being impossible with these, the purchase of a ball mill to replace rolls, screens, and elevator is recommended. It is estimated that a saving of $1,200 per month can be made on the basis of 80 tons milled per day, and even better results may be obtained by careful work.

*Rand district.*—A number of properties were actively engaged in prospecting throughout the year 1916. The Copper Mountain was the largest producer of copper ore containing gold and silver. Small quantities were also shipped from the Golden Pen, Morning Glory, Meadow Lark, and Black Hills properties.

*Rawhide district.*—Reports from 7 producers showed an output of $70,454 in gold and silver. The Nevada New Mines Co., besides treating some of its own ore, treated a large quantity from the Black Eagle property, recently purchased.

*Santa Fe district.*—Nineteen producers reported an output of 17,665 tons of ore, all of which, with the exception of 53 tons treated at a gold and silver mill, was of shipping grade. The metallic output of the ore consisted of $1,222 in gold, 46,755 ounces of silver, and 2,547,058 pounds of lead, valued in all at $658,563, or an average value per ton of $37.28. In 1915 there were 2,726 tons of ore produced having an average value per ton of $27.09. The Wall Street & Turk property was the principal producer of copper ore carrying some silver. Other producers of importance were the Calavada, Tip Top, Mayflower, Anderson, Champion, Never Sweat, Cuba, Vacation, and Table Mountain.

*Silver Star district.*—There were 1,485 tons of ore produced by 20 operators, all of which, with the exception of 85 tons treated at a gold and silver mill, was of shipping grade. The district output

[1] Eng. and Min. Jour., July 28, 1917, p. 155.

contained $6,461 in gold, 8,252 ounces of silver, 190,567 pounds of copper, and 7,906 pounds of lead, valued in all at $59,316, or an average value per ton of $39.94. In 1915 there were 2,016 tons of ore produced in the district, with an average value per ton of $27.20. The Olga property was the principal producer of copper ore containing silver. Other producers shipping small lots were the Aureola, Blue Jacket, Copper Dike, Copper King, Lost Mine, and Moho.

*Walker Lake district.*—Only 2 producers reported a small quantity of gold ore, part of which was treated in a stamp mill at the Wheeler mine in the Pine Grove district.

## NYE COUNTY.

*Mine production in Nye County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 119 | 630,987 | $2,956,380 | 10,220,018 | 2,345 | 201,982 | $8,147,832 |
| 1916 | 100 | 564,450 | 2,505,714 | 8,868,267 | 6,023 | 135,355 | 8,351,855 |
| Increase or decrease, 1916 | | −66,537 | −450,666 | −1,351,751 | +3,678 | −66,627 | +204,023 |

[a] Includes placer production.

The output of 564,450 tons of ore was reported in 1916 by 73 operators of deep mines. This is 66,537 tons less than was reported by 72 operators in 1915. The total average value per ton increased from $12.58 in 1915 to $14.47 in 1916. The value for both years is practically that of the gold and silver. Nearly all of the ore (532,304 tons) was treated at gold and silver mills, and yielded bullion containing $2,200,221 in gold and 8,142,025 ounces of silver, having an average value per ton of $14.20, and 1,412 tons of concentrates, which were shipped to smelter. These and 442 tons of concentrates produced at concentration mills contained $118,119 in gold, 690,248 ounces of silver, 1,550 pounds of copper, and 3,712 pounds of lead, having a total value of $572,939, or an average value per ton of $309.02. The ore of shipping grade amounted to 751 tons and contained $7,902 in gold, 29,014 ounces of silver, 4,473 pounds of copper, and 131,643 pounds of lead, valued in all at $37,176, or an average value per ton of $49.50. The placer gold reported from 27 operators amounted to $179,165 in gold and 4,501 ounces of silver, against a production in 1915 of $204,714 in gold and 4,462 ounces of silver.

*Antelope Springs district.*—During 1916 a small quantity of silver ore containing a little gold was shipped from the Antelope View property.

*Bellehellen district.*—The Clifford mine was a producer of gold and silver contained in ore cyanided. There was also a small shipment of rich concentrate. The mine was closed in September on account of a shortage of water.

*Belmont or Philadelphia district.*—A considerable quantity of mine dump ore, which had been taken out of the Monitor-Belmont

property during its earlier operations, was treated in the 100-ton concentration and flotation mill on the property. The concentrate shipped was unusually rich in silver.

The Belmont camp, originally organized as the Philadelphia district, was discovered and mining was begun in 1864 on the Transylvania claim. The district is said to have held rank as a large silver producer, and during 20 or more years of its activity to have yielded more than $15,000,000, the ores being treated at the Belmont by the Boss continuous-pan process. There was a period, from 1885 to 1906, when the camp was dormant, and after this time mining began to grow until it reached the present stage of its development. The character of ore deposits and minerals was recently discussed[1] as follows:

In 1885 the declining price of silver, together with increased cost of pumping as depth was attained, and the lower grade of the deeper ore, forced a suspension of the work and the mines were closed down.

The old operating companies made use of the Boss pan-amalgamation process for ore treatment, and for the carrying out of this process there were three large mills in the camp of solid brick construction, with tall brick smoke-stacks that even now dominate the landscape. So far as can be ascertained, the ores treated were silver chloride, with some stetefeldite and other sulphides. The value of the silver content varied from $25 to $250 per ton, which, with silver at the price of those times, would give approximately a minimum of about 25 ounces.

The Monitor-Belmont Mining Co. now controls all the old district, comprising 33 claims, water rights, mill rights, etc. Electric power was brought into the camp, and the erection of a 100-ton mill to treat the old dump was begun, while exploration and development of the underground workings was in progress.

The mill, completed in 1915, was actively at work during 1916. Flotation treatment of old silver dump ores that had been exposed to the weather for at least 30 years presented problems that were of a highly interesting nature technically, but they were all solved up to a point where the dump treatment was economically possible. The average tonnage of 120 tons per day of 24 hours is crushed by ten 1,600-pound stamps.

The early workers had left a large amount of underground work already accomplished, which, although filled with water to a considerable height, was of much assistance in the development of the property. * * *

The development of the property is to be carried out thoroughly and promptly. A compressor and air drills are being installed, and the mill is changed so as to meet the requirements of the ore. The Highbridge-Belmont vein averages from 3 to 20 feet in thickness and has been proven for a length of 2,400 feet. The depth, as shown by the old workings, is at least 500 feet in the Belmont and Highbridge shafts, but, of course, there are no data on the value of the ore in the vein below this point. Another vein, the Eldorado South, has been opened by workings to a depth of more than 500 feet and over a length of 1,400 feet. The Arizona vein is known over a length of 1,000 feet and a depth of 200 feet. The company intends to develop vigorously all these possibilities.

The geology of the portion of the district owned by the Monitor-Belmont Mining Co. may be briefly described as quartz veins and lenses occurring in slates and limestones at or near their contact with intrusive siliceous granites. The alteration of the intruded rocks to mica schists and jasperoid is noticeable. The metallic minerals occur in the quartz as bunches; no banding has been noticed. The silver contents are chiefly derived from stetefeldtite, an argentiferous antimonial copper ore, with lead and silver carbonates, silver chloride, etc.

The camp is 51 miles from Tonopah, which is the nearest railroad point and from which all freight has to be hauled by auto truck and horse teams. Early day supplies were hauled by ox wagon from Sacramento, Cal. Belmont at one time was county seat of Nye County and still retains the fine brick courthouse as a tangible sign of her former grandeur. Ten thousand people lived and worked in the district then; now her population numbers about 80, but she has hopes.

[1] The Belmont camp, Nev.: Eng. and Min. Jour., June 9, 1917, p. 1007.

*Bullfrog district.*—Eleven producers reported the output of 9,880 tons of ore, all of which was of milling grade with the exception of 124 tons containing gold, silver, copper, and lead, shipped directly to the smelters. The district output contained $40,090 in gold, 3,794 ounces of silver, 2,554 pounds of copper, and 4,500 pounds of lead, valued in all at $43,526, or an average value per ton of $4.41. The principal productions of the district were from the Tramp & Eclipse properties. The ore was treated in a 60-ton cyanide mill. Smaller productions came from the Polaris, National Bank, and Pioneer Consolidated properties.

*Cloverdale district.*—Shipments of silver ore were made from the Rosalie prospect, which is opened to a depth of about 200 feet. About 1½ miles south of this property, the Orizaba mine yielded a small quantity of silver ore carrying gold.

*Cactus Range district.*—The Fairday property, opened by a vertical shaft 100 feet deep, yielded a small shipment of silver ore containing gold.

*Ellsworth district.*—A quantity of old tailings from the Ellsworth mill, containing gold and silver, but principally silver, were treated in a 30-ton cyanide plant.

*Gold Crater district.*—The Gold Prince property, equipped with a 25-ton amalgamation and concentration mill, produced a small quantity of gold and silver bullion. Besides this, there was shipped directly to the smelter some silver ore carrying gold.

*Golden Arrow district.*—The Cotter property yielded a few tons of ore, which was treated by cyanidation at the West End mill, situated at Tonopah.

*Johnnie district.*—The treatment by amalgamation of a small tonnage of gold ore was reported by a lessee on the Johnnie property.

*Manhattan district.*—Eleven deep mines and 25 placer producers reported gold and silver amounting to $199,566, against an output in 1915 valued at $294,769. In 1916 there were 41,725 tons of ore milled, which yielded by amalgamation and cyanidation bullion containing $121,261 in gold and 2,844 ounces of silver, valued in all at $123,132, or an average value per ton of $2.95. The total placer bullion amounted to $75,359 in gold and 1,380 ounces of silver, against a production in 1915 of $132,132 in gold and of 2,454 ounces in silver. Among the placer operators were the Cornucopia Fraction, Bulldog, Black Cat, African, Edith, Independence, Fairview, Georgia, Iron King, Japan, Last Chance, Polaris, Rainbow, Robust & Erwin Fraction, Bright August, Searchlight, September, Top Knob, Thursday Fraction, and various other smaller producers.

The deep mine output in 1915 was valued at $160,064 in gold and 2,621 ounces of silver, or an average per ton of $3.43. Work progressed at the Big Pine, Big Four, Union Amalgamated, and other properties, but development was particularly encouraging at the White Caps. At this property recent discoveries of good ore on the 300-foot level caused the deepening of the 310-foot shaft to 435 feet. Foundation for the roasting plant is under construction and the mill will be moved to a site nearer the mine. A recently published article[1] gives an interesting account of the development in the White Caps mine as follows:

[1] The White Caps mine, Manhattan, Nev.: Min. and Sci. Press, Dec. 16, 1916, p. 884.

Oxidized gold ore was discovered on the surface of the White Caps claim, and an incline shaft was sunk to a vertical depth of 200 feet. Water level was at 150 feet, and below that point the ore changed to massive sulphide. The oxidized ore can be readily cyanided, while the sulphide ore is not amenable to direct cyanidation.

In 1912 a party of lessees erected a mill and cyanide plant of 75 tons daily capacity. For a time a good production was made, but when the oxidized ore was exhausted the mine and mill were closed, except for a few shipments, to smelters, of selected high-grade sulphide ore. A process has been designed recently for treating the sulphide ore by roasting and cyaniding, and a roaster is now bing added to the mill. * * *

The mine is now operated through a vertical two-compartment shaft, sunk in the hanging wall of the ore bodies. There are levels at 100, 200, and 300 feet. The total production to date is 19,909 tons of ore, assaying $19.14 in gold, or $381,053 gross. This was almost all oxidized ore from above the 200-foot level.

The ore deposits occur in the sediments, and are of three types, as follows: (1) Small gold-bearing veins, with a gangue consisting principally of quartz and calcite; (2) low-grade disseminations of free gold throughout the cleavage planes of the schist; and (3) replacement deposits in the limestone.

It is to the third type that the White Caps ore bodies belong. The ore is a replacement of limestone by quartz, pyrite, arsenopyrite, and stibnite. Calcite, due to re-crystallization of the limestone, is abundant. Realgar is common, and cinnabar occurred in small quantities above the 200-foot level, but has not been found below it.

*Millett district.*—Two producers reported 26 tons of ore, which was shipped to the smelter and yielded $489 in gold, 1,833 ounces of silver, 5,232 pounds of lead, and a little copper, valued in all at $2,060. The producers were the Mammoth Contact and the H. & H. properties.

*Reveille district.*—The Southwestern Nevada property was operated under lease, and a small output of lead ore carrying silver was shipped to the smelter.

*Round Mountain district.*—The reports of 8 deep mines gave a production of 29,927 tons of ore, containing $212,072 in gold and 8,505 ounces of silver, valued in all at $217,668, or an average value per ton of $7.27. Reports from 2 placer producers gave $103,806 in gold and 3,121 ounces of silver. The total output of the district was valued at $323,528. The larger part of this production was from the properties of the Round Mountain Mining Co. Production was also reported from the Alta, Fairview, Blue Jacket, Seevers, and Silver Bell properties.

The Round Mountain Mining Co., according to its annual report,[1] produced 67,452 tons of gold ore between March 31, 1915, and December 31, 1916, yielding bullion valued at $357,014 in gold and silver recovered in an amalgamation mill. The average value of the ore during the first part of the above period was $5.677, tailings loss $0.742, and the extraction, $4.935 per ton. During the second period the average of the ore mined and milled was $7.104, tailings loss $0.868, and the extraction $6.236 per ton. In addition to this output, lessees mined 20,127 tons of ore. The placers yielded by hydraulicking since April 1, 1915, the beginning of its new operations, $139,912.16 in gold and silver, recovered from 175,477 yards of dirt, or an average of $0.797 per yard at a cost of $0.471 per yard. The following paragraphs are taken from the company's report:

The final clean-up of the main tailrace and branch races was made in December. In the main race the riffles and wooden lining blocks were removed

[1] Round Mountain Mining Co. Tenth and Eleventh Ann. Rept., to end of year Dec. 31, 1916.

and 36 tons of concentrates recovered. This material, which contained pieces of high-grade ore, nuggets, amalgam, and free gold, was milled at the plant of the Los Gazabo Mill Co., and yielded $6,696.70, or $186.02 per ton. The total clean-up from the races amounted to $9,026.70.

As is well known, the character of the Round Mountain placer deposit is unique, it being what may be termed a hillside placer consisting of the detritus resulting from the erosion of the rhyolite and veins and stringers. The placer gold may be classified as follows: Free gold, both coarse and fine nuggets, free gold contained in cemented detritus and released only on thorough disintegration of the cement, gold particles or aggregates associated with quartz, oxides of iron, or rhyolite, and gold associated with gangue in cemented detritus.

Tests made on placer tailings indicate an extraction of approximately 60 per cent of the total value contained, and it has been ascertained that the loss is chiefly in cemented material and in gold associated with gangue.

*San Antone district.*—This district, 14 miles north of Millers, yielded ores from the Hudson property, shipped directly to the custom milling plant near Millers, where the ore was treated by cyanidation, yielding gold and silver bullion. A small quantity of copper ore was also produced and shipped directly to the smelter.

*Tonopah district.*—

*Mine production of Tonopah district, Nevada, 1904–1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 22 | 516,337 | $2,228,963 | 10,171,374 | ..... | ..... | $7,385,870 |
| 1916 | 21 | 455,140 | 1,941,441 | 8,734,726 | ..... | ..... | 7,688,891 |
| Increase or decrease, 1916 | ..... | −61,197 | −287,542 | −1,436,648 | ..... | ..... | +303,021 |
| Total, 1904–1916 | ..... | 4,313,604 | 23,433,203 | 106,897,676 | 12,113 | 214,523 | 84,969,807 |

Twenty-one producers reported in 1916 an output amounting to $7,688,891, against an output by 22 producers in 1915 amounting to $7,385,870. The quantity of ore mined decreased from 516,337 tons in 1915 to 455,140 tons in 1916. The total average recovery value per ton of the ore produced was $16.89, against an average recovery value of $14.30 in 1915. Nearly all of the ore (450,264 tons) was treated in cyanidation plants, some of which were equipped for concentration. Altogether there were 1,411 tons of gold and silver concentrates produced. The mill bullion produced amounted to 88,163.94 ounces of gold and 8,113,674 ounces of silver, and the concentrates contained 5,686.10 ounces of gold and 608,697 ounces of silver. Only 281 tons of ore, containing a small quantity of gold and silver, were shipped to smelters. The average bullion recovery per ton of ore cyanided was valued at $15.90 and the average value of the concentrates per ton was $367.16. There were 372 tons of sweepings from the mill ponds, some of it being re-treated and the remainder shipped to the smelter. The sweepings contained 67.53 ounces of gold and 11,023 ounces of silver. The principal properties producing in the district in order of size of output were the Belmont, Extension, Tonopah Mining, Jim Butler, West End, Rescue Eula, Montana-Tonopah, Halifax, Midway, McNamara, and North Star.

The Tonopah-Belmont mine[1] during its fiscal year produced 180,419 wet tons of crude ore, from which 17.13 per cent of rock was culled, leaving 144,762 dry tons to be milled by cyanidation. This ore averaged per ton 0.20 ounce of gold, 19.70 ounces of silver, and in value $17.54, as compared with 0.196 ounce of gold, 19.6 ounces of silver, valued at $13.88 in 1915. Dividends paid by the company in 1916 amounted to $750,017.56. The annual printed report of the company gives the following information:

> The metals recovered by the milling of the Tonopah ores aggregated 27,831.437 ounces of gold and 2,629,465.57 ounces of silver, a reduction from the totals recovered in the previous year of 3,280.992 ounces of gold and 339,099.21 ounces of silver. The entire gold production was sold at an average price of $20.5168 per ounce (24,684.472 ounces in bullion at $20.6718 per ounce and 3,146.965 ounces in concentrates at $19.30 per ounce). Of the 2,629,465.57 ounces of silver produced the silver in concentrates (388,801.34 ounces) was sold to the smelters at an average of 66.2 cents per ounce. The production of silver as bullion was 2,240,664.23 fine ounces. * * *
>
> The Belmont mine and mill at Tonopah were operated continuously throughout the year with but one major interruption, due to the failure of electric power, the Tonopah mill operating on Belmont mine ores exclusively. The Millers cyanide plant, as in the previous fiscal year, was operated as a custom mill on ores originating at Tonopah and the neighboring country, and, with the exception of several stoppages from power interruptions, ran continuously throughout the period. A small 30-ton daily capacity retreatment plant, for the beneficiation, by cyanide, of the sweepings products from slime ponds, was built during the year and was successfully operated from June until the end of the "sweeping season" in December. * * *
>
> The policy announced by your management two years ago of storing silver bullion as produced and selling as market conditions were favorable was adhered to for the first half of the fiscal year. On September 1, 1916, the market appeared to have fully recovered its stability, and all silver produced since then has been sold at the market price as produced. At the beginning of the fiscal year there were in storage 946,759 ounces of silver bullion, which, together with that produced during the first half of the fiscal year, has been gradually reduced as market conditions warranted to 356,628 ounces in storage at the close of the fiscal year. All stored silver has been carried on the books at 50 cents per ounce and the profit on sales over that figure during the year amounted to $125,262.01, which has been credited to the income account. The profit for the previous year was $54,981.46, so that the total profit on sales of stored silver to the close of the fiscal year was $180,243.47.

At the Tonopah Mining Co.'s property,[2] according to its annual report, there were milled by cyanidation 81,782 dry tons of ore containing a total of 15,636 ounces of gold and 1,387,557 ounces of silver, valued at $1,279,157.86. The average recovery was 94.2 per cent of the gold and 90.3 per cent of the silver. The mine ore (74,990 tons) averaged $15.67 per ton and the dump ore (5,542 tons) $15.06 per ton. Mining costs and costs of handling dump ore were $4.61 and milling $3.16. The metal losses in melting and refining were $1.34, and the profit per ton was $5.60. Dividends paid during the calendar year amounted to $600,000.

The Tonopah Extension property[3] reports having mined and milled during its fiscal year 109,402 tons of ore containing 2,068,650 ounces of silver (averaging 18.908 ounces per ton) and 19,622.40 ounces of gold (averaging 0.179 ounce per ton). The average price received was

[1] Tonopah-Belmont Development Co. Fourteenth Ann. Rept., for year ending Feb. 28, 1917.
[2] Tonopah Mining Co. of Nevada Fifteenth Ann. Rept., for year ending Dec. 31, 1916.
[3] Tonopah Extension Mining Co. Ann. Rept., for year ending Mar. 31, 1917.

$0.70867 per ounce for silver and $20.6718 per ounce for gold, making the total value per ton of the ore mined and milled $17.107, of which $13.405 was silver and $3.702 was gold. The mining cost per ton was $4.90; milling, $3.623; metal losses in tailing, $1.503; freight, express, and refining, $0.296, or a total cost of $10.322 per ton and a total profit per ton of $6.785.

From the West End property[1] 32,009 tons of ore were milled containing 6,061.62 ounces of gold, 596,186.88 ounces of silver, valued at $526,037.15, or an average value of $16.43 per ton. The total average cost incident to the production and treatment of the ore was $11.06 per ton, and the profit was $5.37 per ton.

*Troy district.*—The Sunrise property, near Currant post office, produced lead ore carrying some silver and a little copper. The property is opened by an adit 145 feet long.

*Union district.*—The old Blue Bell tailing dump produced a small quantity of gold and silver recovered by the cyanidation process. There was also some ore treated from the Oddie property.

## ORMSBY COUNTY.

Three deep-mine producers reported 107 tons of ore, which is 400 tons less than was produced in 1915 at 4 mines. The total average value was the same as in 1915, and the gold and silver value increased from $3.98 to $6.15 per ton. Included in the total output were 100 tons of old tailings treated by cyanidation. The remainder was shipped directly to the smelter.

*Carson River district.*—Small quantities of bullion continue to be extracted from old tailings lodged along Carson River from the early operations of mills of the Comstock mines.

## STOREY COUNTY.

*Mine production in Storey County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 23 | 85,144 | $298,990 | 156,645 | 531 | 4,873 | $378,731 |
| 1916 | 24 | 63,187 | 483,137 | 285,827 | 903 | 11,057 | 672,196 |
| Increase or decrease, 1916 | | −21,957 | +184,147 | +129,182 | +372 | +6,184 | +293,465 |

Twenty-four producers reported the production of 63,187 tons of ore. This is 21,957 tons less than was reported by 23 producers in 1915. The total average value per ton increased from $4.45 in 1915 to $10.64 in 1916. Practically all of this value was for gold and silver content. The bulk of the ore, 55,656 tons, was treated at gold and silver mills and yielded $456,285 in gold and 269,856 ounces of silver, having an average value per ton of $11.39. This ore also yielded 111 tons of gold and silver concentrate containing copper and lead. There were 189 tons of ore treated at concentration mills,

[1] West End Consolidated Mining Co. Tenth Ann. Rept., for year ending Dec. 31, 1916.

from which was recovered 79 tons of concentrates. The concentrates contained $24,375 in gold, 13,212 ounces of silver, 903 pounds of copper, and 11,057 pounds of lead, valued in all at $34,054, or an average value per ton of $152.7. The ore of shipping grade, 123 tons, contained gold and silver and had an average value per ton of $34.89. No placer production was reported.

*Comstock district.*—Reports from 24 producers gave an output of 63,187 tons of ore, of which 55,656 tons were milled at gold and silver mills and yielded bullion and some concentrate, 189 tons were directly concentrated, and 123 tons shipped directly to the smelters. There were 7,219 tons of old tailings treated by cyanidation. The district output contained $483,137 in gold, 285,827 ounces of silver, 11,057 pounds of lead, and 903 pounds of copper, valued in all at $672,196, or an average value per ton of $10.64. The principal ore producers were the Chollar & Potosi, Sierra Nevada, Cedar Hill, Union Consolidated, and the Jacket-Crown Point-Belcher mines.

On May 23 a fire occurred in the Yellow Jacket shaft on Gold Hill, and the mine closed, the mill being operated on the old dumps. All other work on Gold Hill was done through the Challenge-Imperial shaft. In the Virginia City section, the principal change was at the Combination shaft, where the "middle mines" formed an association and began unwatering properties. In the north-end mines the principal production was from the Union mine, the ore going to the Mexican mill.[1]

## WASHOE COUNTY.

The output of ore by 28 producers aggregated 5,061 tons, 57 tons less than was produced by 22 producers in 1915. The total average value per ton increased from $11.65 in 1915 to $25.68 in 1916, and the gold and silver value in the ore from $9.55 to $14.19. The greater part of the ore was milled and yielded lead concentrate containing principally silver and having an average value of $139.60 per ton. Ore treated at gold and silver mills, 1,174 tons, produced gold and silver bullion amounting to $30,232 in gold and 674 ounces of silver, with an average value per ton of $26.13. No production was reported from placers.

*Leadville district.*—The Tohoqua was the principal mine in the district and produced lead ore containing much silver, which was treated in the company's 75-ton concentration mill. Outputs from four other mines were credited to the district.

*Peavine district.*—From the Nixon-Nevada property considerable copper ore containing silver and gold was shipped directly to the smelters. The Silver Top and the Wedekind properties were also producers.

*Pyramid Lake district.*—Copper ore carrying silver was shipped from the Providence property.

*White Horse district.*—The output of the district, as reported by various producers, aggregated 1,145 tons of ore, which contained $31,913 in gold and 1,492 ounces of silver, valued in all at $32,895,

[1] Eng. and Min. Jour., Jan. 6, 1917, p. 72.

or an average value per ton of $28.73. There were only 20 tons of ore shipped directly to the smelter. All of the remaining ore was treated at milling plants in the district and yielded gold and silver bullion and a small quantity of concentrate. The largest production of ore came from the Greenhill and Texas properties.

## WHITE PINE COUNTY.

*Mine production in White Pine County, Nev., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine oz.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 51 | 3,207,981 | $620,579 | 112,934 | 64,682,966 | 1,603,740 | 42,651 | $12,078,021 |
| 1916 | 41 | 4,056,257 | 743,049 | 147,110 | 93,107,945 | 1,641,066 | 24,494 | 23,860,917 |
| Increase or decrease, 1916 | ..... | +848,276 | +122,470 | +34,176 | +28,424,979 | +37,326 | −18,157 | +11,782,896 |

[a] Includes placer production.

The greater part of the ore mined in the county is produced from one property. Forty-one operators reported the production of 4,056,257 tons of ore, or 848,276 tons more than was produced in 1915, as reported by 51 operators. The total average value per ton increased from $3.76 in 1915 to $5.88 in 1916, and the gold and silver value in the ore was 21 cents in both 1915 and 1916. The bulk of the ore, 3,974,053 tons, was treated at concentration mills and yielded 531,744 tons of concentrates, of which 531,572 tons were copper concentrates and 172 tons were lead concentrates. The total average value per ton, including the lead, was $42.25. There were 81,817 tons of ore directly smelted, which contained $28,328 in gold, 42,850 ounces of silver, 5,027,081 pounds of copper, 1,377,129 pounds of lead, and 24,494 pounds of zinc, valued in all at $1,391,489, or an average value per ton of $17.01. There were 334 tons of old tailings and slag smelted, yielding gold, silver, copper, and lead. Gold and silver bullion was produced from 53 tons of ore treated at milling plants. The placer output amounted to $696 in gold and 7 ounces of silver, against an output reported in 1915 of $2,395 in gold and 20 ounces of silver.

*Aurum district.*—The Lucky Deposit mine was operated a large part of the year, and a small quantity of copper ore carrying silver was shipped to the smelter.

*Cherry Creek district.*—Reports from four producers show an output of 184 tons of ore containing principally lead with some gold and silver, valued at $6,871.

*Duck Creek district.*—Eleven deep-mine producers reported 367 tons of ore containing 476 ounces of silver, 354,504 pounds of lead, and 24,494 pounds of recoverable zinc. This, with a small quantity of copper and gold, was valued at $28,109, or an average value per ton of $76.59. In 1915 there were 472 tons of ore produced, which had an average value per ton of $49.35. All the ore produced in 1916 was of shipping grade and came principally from the Ely Gibralter, Keepan, Ely Amalgamated, Lead King, Santiago, McGill, and Homestake properties.

*Eagle district.*—The April Fool claim was worked and yielded a small output of lead ore containing silver.

*Hunter district.*—The Hunter property produced considerable copper-lead ore containing silver and gold.

*Osceola district.*—The Piermont and the Pea Ridge were the only producers of ore in 1916. The latter property is equipped with a 2-stamp amalgamation and concentration mill, from which tungsten concentrates were also produced.

*Robinson (Ely) district.*—The Nevada Consolidated, the largest producer of copper in the State, continued to produce heavily in 1916. Renewed activity at the Consolidated Copper Mines Co., which controls the Giroux mine, added a large quantity of copper ore to the district total.

The following table gives a comparison of the production for the last two years and the total output beginning with the year 1904:

***Mine production of Robinson district, White Pine County, Nev., 1904–1916.***

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine oz.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 14 | 3,206,133 | $568,130 | 82,281 | 64,661,610 | 654,905 | 42,651 | $11,961,699 |
| 1916 | 8 | 4,053,950 | 737,964 | 110,802 | 93,044,578 | 92,127 | ..... | 23,706,195 |
| Increase or decrease, 1916 | ..... | +847,617 | +169,834 | +28,521 | +28,382,968 | −562,778 | −42,651 | +11,744,496 |
| Total, 1904–1916 | ..... | 23,734,108 | 3,886,741 | 714,600 | 551,312,884 | 1,492,472 | 42,651 | 93,551,274 |

From the Nevada Consolidated mine[1] 90,735,287 pounds of copper were produced, as compared with 62,726,651 pounds in 1915. The following paragraphs are taken from the company's report:

During the year operations were continued in the Ruth mine and in December the production was brought up to an average of about 2,500 tons per day. The shrinkage-stope system of mining was gradually displaced by the branch-raise caving system, as the latter was found to be better adapted to the peculiarly soft ore and heavy ground in this deposit. The principal difficulty with the shrinkage-stope system was met in keeping the horizontal workings open when located so near the zone of active mining. While this system could be successfully combatted, it involved heavy upkeep expense. The branch-raise system permits placing the extraction drifts from 40 to 80 feet below the zone of active mining, and so far in its use it has been much less difficult and expensive to maintain the horizontal workings. In neither system have we experienced serious difficulty in keeping the inclined or vertical workings open. During the year 591,545 tons of ore averaging 2.195 per cent copper were shipped to the concentrator from the Ruth mine.

Steam shovel operations were conducted as usual in what is now one pit, the two original pits having been connected. The greater part of the tonnage was taken from the central and western portions, formerly known as the Hecla and Liberty areas. The amount of sulphide concentrating ore shipped during the year was 27.65 per cent greater than in 1915, and was made up as follows:

[1] Nevada Consolidated Copper Co. Tenth Ann. Rept., for year ending Dec. 31, 1916.

*Operations of Nevada Consolidated copper mine, 1915–16.*

| | 1915. | | 1916. | |
|---|---|---|---|---|
| | Short tons. | Percentage of copper. | Short tons. | Percentage of copper. |
| Pit ore | 2,991,782 | 1.52 | 3,337,570 | 1.532 |
| Ruth mine ore | 86,029 | 2.28 | 591,545 | 2.195 |
| | 3,077,811 | 1.54 | 3,929,115 | 1.632 |

In addition to the above, 79,963 tons of siliceous carbonate ore, averaging 3.1 per cent copper, were shipped direct to smelters—45,591 tons to the company's smelter and 34,372 tons to Garfield, Utah. * * *

The total mining cost by steam shovel of concentrating ores was 23.70 cents per dry ton. Of this amount 11.28 cents is Federal, State, county, and Federal corporation income taxes, leaving a balance of 12.42 cents per ton, which covers all other charges—labor, supplies, repairs, management, and a proper portion of New York and Nevada overhead charges. In 1915 this mining cost was 15.24 cents per ton, of which 4.08 cents per ton was for the above mentioned taxes, all of which are charged to mining, leaving a balance of 11.16 cents per ton to cover the direct mining cost. There was, therefore, an increase in the direct mining cost for 1916 of 1.26 cents per ton, equivalent to 11.16 per cent over the cost obtained in 1915. * * *

During the year many improvements at the concentrator have been made, both for the purpose of increased tonnage and improved recoveries. These consisted principally in the replacing of Huntington and Chilean mills with tube mill type regrinding equipment. A considerable number of double-deck tables and other apparatus was installed for the purpose of increasing concentrating capacity. The old coarse crushing department of the concentrator is inadequate for the present plan for milling about 14,000 tons daily. In order to meet this requirement the construction of a new coarse crushing plant was started in July, 1916. This will be operating by June 1, next. The total tonnage milled during 1916 was 3,922,634 tons, averaging 1.632 per cent copper, with an actual mill extraction of 73.87 per cent, the ratio of concentration being 7.45 and the average copper in concentrates 8.98 per cent. * * *

Total milling costs for the year were 55.9 cents per ton as against 53.3 cents for the year 1915. * * *

The net operating cost per pound of copper produced was 9.44 cents. Miscellaneous earnings for the year amounted to 1.31 cents per pound, which, if deducted from the actual operating cost above stated, leaves a final net cost of 8.13 cents per pound.

The Copper Mines Co.[1] controlling the Giroux and Ora mines, produced from its property 1,196,702 pounds of copper, which was marketed at an average price of 24 cents per pound. There was also some gold and silver, which was added to the values recovered. Some details follow from the company's annual report:

The old concentrator at Kimberly has been remodeled with equipment embodying the most recent improvements in copper concentration, and was placed in operation early in February of this year. The capacity of this first unit was 500 tons per day, and the results of its operation were so satisfactory that the construction of another 500-ton unit was authorized, which is now being installed and will bring the total capacity of the plant up to 1,000 tons per day.

A contract has just been entered into which the Nevada Consolidated Copper Co., under the terms of which the Nevada Co. agrees to mine and treat for our account, from the Ora claim, 425,000 tons of ore during the period ending August 15, 1918, and after that date at the rate of at least 75,000 tons per year for a period of 5 years. The Nevada Co. further agrees to treat at its Steptoe

[1] Consolidated Copper Mines Co. Ann. Rept. for year ending April 30, 1917.

reduction works all the concentrates produced by our Kimberly mill, together with high-grade direct smelting ore up to a total tonnage (concentrates and direct smelting ore combined), of 4,500 tons per month, for a term of five years from May 1, 1917. * * *

Our estimates, based on churn drill sections, of tonnages and grades of porphyry ore developed and partially developed. and reported in our annual report under date of April 30, 1916, were: 25,867,850 tons of 1.141 per cent ore. * * *

Our estimates of tonnages and grades of ore now developed and partially developed are: 27,164,426 tons of 1.19 per cent ore.

The above figures deal with porphyry ores only and no attempt has been made to estimate or include tonnages and grades of direct smelting ores known to exist in the Old Glory, Taylor, and contiguous ground. Early in March, however, the 1,000-foot level of the New Giroux shaft was unwatered through the natural course of supplying our concentrator, and the board of directors authorized the opening up of the 1,000-foot level from the New shaft leading over under the Old Glory hill. While this work was being carried on several strata of ore previously cut were also opened up, and in following the same it was found that they formed a series of deposits of high-grade, direct-smelting ore, varying from 2 to 16 feet in width; 300 tons of this ore, averaging 12 per cent, were shipped during the month of March, and 650 tons of the same grade were shipped during the month of April, all extracted during the course of ordinary mining development operations. and a substantial tonnage of this ore is now in sight ready for stoping and shipment.

*White Pine district.*—Eight deep mine producers reported the output of 1,199 tons of ore, containing $1,427 in gold, 20,592 ounces of silver, 10,838 pounds of copper, and 1,009,513 pounds of lead, valued in all at $87,299, or an average value per ton of $72.81. There were 508 tons treated at concentration mills, yielding 172 tons of lead concentrate shipped directly to the smelter with 691 tons of crude ore containing lead, silver, and copper. The Nevada mine, situated on the east slope of White Pine Mountain, was the principal producer of milling ore and also yielded considerable lead ore of shipping grade. The Young Treasure and White Pine properties were also producers of lead-silver ore. There was a small output of copper and lead oxidized ores from the Grandelmeyer-Imperial property.

# ARSENIC.[1]

By JOSEPH B. UMPLEBY.

The production of arsenic in the United States in 1916, as in 1915, exceeded that of any previous year, amounting to 5,986 short tons, valued at $555,187, an increase over 1915 of less than 9 per cent in quantity and of nearly 84 per cent in value.

In the table below the production of arsenic in the United States is shown since the opening of the first plant at Everett, Wash., in 1901 to the end of 1916. In 1916 the production came from five plants operated by three companies.

*White arsenic ($As_2O_3$) produced in the United States, 1901–1916.*

| Year. | Quantity (short tons). | Value. | Year. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| 1901 | 300 | $18,000 | 1909 | 1,214 | $52,946 |
| 1902 | 1,353 | 81,180 | 1910 | 1,497 | 52,305 |
| 1903 | 611 | 36,691 | 1911 | 3,132 | 73,408 |
| 1904 | 36 | 2,185 | 1912 | 3,141 | 190,757 |
| 1905 | 754 | 35,210 | 1913 | 2,513 | 159,236 |
| 1906 | 737 | 63,460 | 1914 | [b] 4,670 | 313,147 |
| 1907 | 1,751 | 163,000 | 1915 | [c] 5,498 | 302,116 |
| 1908 | (a) | (a) | 1916 | [d] 5,986 | 555,187 |

[a] Only two firms produced arsenic in the United States in 1908, so that the figures can not be published without disclosing confidential returns.
[b] This quantity includes 200 tons of crude arsenic trioxide carrying about 97.5 per cent $As_2O_3$.
[c] This quantity includes 353 tons of crude arsenic trioxide carrying about 97.5 per cent $As_2O_3$.
[d] This quantity includes 152 tons of crude arsenic trioxide carrying about 97.5 per cent $As_2O_3$.

The refined arsenic produced is reported to be above 99.5 per cent $As_2O_3$.

Imports of white arsenic and arsenic sulphide, or orpiment, decreased from 3,183 short tons to 2,163 short tons, or 32 per cent. Thus the total supply in 1916, as compared with 1915, fell from 8,681 short tons to 8,149 short tons.

Of the total imports of arsenic into the United States by far the largest quantity comes from Canada, where it is derived as a by-product in the smelting of ores from Cobalt and adjacent silver deposits in northern Ontario. In the following table the total imports of arsenic compounds into the United States are shown.

[1] A list of publications on arsenic and an extended discussion by F. L. Hess of its occurrences and of field tests for it were published in Mineral Resources of the United States, 1914, pt. 1, pp. 953–964, 1916.

*Arsenic compounds imported and entered for consumption in the United States, 1909–1916.*

| Year. | Arsenic or arsenious acid (white arsenic, $As_2O_3$). | | Arsenic and sulphide of, or orpiment. | | Sheep dip. | | Paris green and London purple. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity. (pounds). | Value. | Quantity (pounds). | Value. |
| 1909 | 445 | $31,235 | 3,591 | $272,493 | 1,574 | $9,615 | 183,765 | $20,370 |
| 1910 | 1,348 | 76,282 | 3,791 | 238,024 | ..... | 24,279 | 181,363 | 14,648 |
| 1911 | 1,921 | 116,948 | 2,175 | 127,375 | ..... | 20,642 | 126,191 | 4,972 |
| 1912 | 3,103 | 200,616 | 3,053 | 228,125 | ..... | 41,556 | 162,272 | 6,950 |
| 1913 | 1,519 | 133,597 | 3,182 | 276,849 | ..... | 40,036 | 99,692 | 4,431 |
| 1914 | 1,594 | 109,121 | 2,034 | 164,592 | ..... | 34,556 | 15,476 | 2,235 |
| 1915 | 1,400 | 113,677 | 1,783 | 154,099 | ..... | 19,916 | 21,056 | 4,069 |
| 1916 | 1,071 | 107,876 | 1,092 | 124,818 | ..... | 20,134 | 23,461 | 5,028 |

It is impossible from information available to group the total imports by countries because the source is recorded for only one of the two principal classes of material. The ports of entry, however, afford a fairly satisfactory idea of the source of the other principal class.

From the table below it will be seen that 87 per cent of the class listed as arsenic and sulphide of, or orpiment, comes from Canada, and that of the arsenic and arsenious acid 96 per cent enters through Buffalo and Michigan and presumably represents Canadian production.

*Arsenic imported into the United States in 1916, by countries and by ports of entry, in short tons.*

| Arsenic and sulphide of, or orpiment. | | | Arsenic or arsenious acid. | | |
|---|---|---|---|---|---|
| Country. | Quantity (short tons). | Value. | Port of entry. | Quantity (short tons). | Value. |
| Belgium | 116 | $18,647 | Buffalo | 986 | $99,823 |
| British Honduras | 0.1 | 26 | Michigan | 45 | 4,495 |
| Canada | 950 | 95,912 | New York | 40 | 3,558 |
| England | 2 | 1,808 | | | |
| France | 17 | 6,517 | | 1,071 | 107,876 |
| Germany | 6 | 696 | | | |
| Mexico | 1 | 1,212 | | | |
| | 1,092 | 124,818 | | | |

The price of white arsenic averaged about 4⅔ cents a pound at the reduction plant. The New York price, as quoted by the Oil, Paint, and Drug Reporter, ranged from 3⅞ cents in January to 8¼ cents in December. During the first 10 months of the year prices in the main ranged from 6 to 6½ cents, but during the last two months there was a marked advance, with little arsenic available for immediate delivery. It is not possible from available data to determine the relative influence of increased demand and decreased supply in causing the rise in price during the year, but it is believed that both factors were operative.

# BISMUTH.

By JOSEPH B. UMPLEBY.

## PRODUCTION.

Only two companies produced bismuth in 1916, the United Metals Refining Co. and the American Smelting & Refining Co., from plants located, respectively, at Grasselli, Ind., and Omaha, Nebr. So far as known to the Geological Survey, ores from Tintic, Utah, supplied most of the metal, although some was also produced from flue dust shipped to Omaha by the Garfield, Utah, copper smelter. Only one carload of bismuth ore is known to have been shipped and this contained considerable gold, silver, and copper.

As in recent years, details of production can not be given, although from data available it seems that the total output is not very different from that in 1915.

The New York price, as quoted in the Engineering and Mining Journal, ranged in 1916 from $3.15 to $4 a pound, or from 15 cents to $1.25 higher than during 1915.

## IMPORTS.

The imports during the year were greater than in 1915, although lower than for several years previous thereto. This is shown in the following table:

*Metallic bismuth imported and entered for consumption in the United States, 1906–1916.*

| Year. | Quantity (pounds). | Value. | Year. | Quantity (pounds). | Value. |
|---|---|---|---|---|---|
| 1906 | 254,733 | $318,452 | 1912 | 182,840 | $316,440 |
| 1907 | 259,881 | 325,015 | 1913 | 117,747 | 213,257 |
| 1908 | 164,793 | 257,397 | 1914 | 90,505 | 165,208 |
| 1909 | 183,413 | 286,516 | 1915 | 44,362 | 108,288 |
| 1910 | 198,174 | 332,668 | 1916 | 76,723 | 195,975 |
| 1911 | 172,093 | 311,771 | | | |

# SELENIUM AND TELLURIUM.

By JOSEPH B. UMPLEBY.

No new developments in the selenium industry came to the attention of the Geological Survey during 1916. It should be borne in mind, however, that this element has very exceptional photo-electric properties and may at any time be made the basis of some war or industrial invention which would greatly increase the demand for it. Selenium is obtained as a by-product in the refining of copper, and it is the opinion of copper metallurgists that if market conditions warranted, its production in this country might be greatly increased.

The value of imports for consumption of selenium and salts of selenium rose from $59 in 1915 to $302 in 1916.

During 1916 the American Smelting & Refining Co. was the only producer of selenium, as against two producers in 1915. The total output was somewhat greater, however, than in 1915.

Prices at the refinery averaged approximately $1.35 a pound, and on the New York market, according to the Engineering and Mining Journal, prices ranged from $2.50 to $5 a pound, largely depending on the quantity purchased.

No production of tellurium in 1916 was reported to the Geological Survey.

# IRON ORE, PIG IRON, AND STEEL.[1]

By ERNEST F. BURCHARD.

## INTRODUCTION.

A period of intense activity in the iron industry, stimulated by the war in Europe, began with the last half of 1915, and this activity continued unabated throughout 1916—in fact, there have been few other years in which high tension has been so steadily maintained. As a result there was a record output of iron ore, pig iron, and steel in 1916, which it may be difficult to surpass without increasing capacity both for mining and transportation of ore and for producing the metals. Heavy shipments of ore from the Lake Superior ports began early, and throughout the season the Lake transportation situation was aided by high water and generally favorable weather and there was good team work between the Lake fleet and the ore-carrying railroads. The result was that more than 64,700,000 gross tons of ore were moved by boat during the season, besides nearly 2,000,000 gross tons carried by rail, the total of 66,658,466 gross tons being an increase of more than 41 per cent over that of 1915. The sustained activity in iron manufacture is indicated by the record of production of pig iron by months, which ranged between 3,000,000 and 3,509,000 gross tons (see fig. 7), the total for the year being 39,434,797 gross tons, compared with 29,916,213 gross tons in 1915, an increase of 32 per cent. The total production of steel increased from 32,151,036 gross tons in 1915 to 42,773,680 tons in 1916, or more than 33 per cent.

An interpretation of the relation of American supplies of iron ore, pig iron, and steel to war needs is presented in a pamphlet recently published by the United States Geological Survey.[2] This paper deals with the conditions in 1914 and later, foreign trade, geographic distribution of deposits of iron ore, iron-ore reserves, importance of conserving iron ore, iron and steel manufacture, and essential geologic and metallurgic studies. These topics will therefore not be discussed in the present chapter. There is, however, an interesting relation between certain data presented in the paper cited, which may be pointed out here. In the table showing the estimated quantity of iron ore in the United States and foreign countries bordering the Atlantic Ocean, the maximum quantity of iron ore of present-day commercial grade credited to the United States is given as about

[1] The statistics in this chapter were compiled by Miss M. B. Clark, with the exception of imports and exports, which were compiled by J. A. Dorsey, both of the United States Geological Survey.

[2] Burchard, E. F., Our mineral supplies—Iron: U. S. Geol. Survey Bull. 666-V, 12 pp., 1917.

7,550,000,000 tons, and in 1916, according to the statistics of the United States Geological Survey, more than 75,000,000 tons of iron ore was mined, or about one one-hundredth of the maximum total reserve. At this rate of mining, therefore, if there were no further discoveries of iron ore in the United States the apparent supply of ore of commercial grade would be exhausted in about 100 years. The rate for 1916 is, however, above the average for the last five years, which is less than 58,000,000 tons annually, and at that rate the ore under consideration would last 130 years. On the other hand, there are reasons for believing that during the next 10 years, at least, the average annual production will show an increase. Whether the present annual rate of increase can be long maintained is questionable. If it were, the duration of supplies of iron ore of present commercial grade in the United States would be relatively short. Too pessimistic a view of the situation should not be taken, however, for there are certain factors that may aid in prolonging the life of the iron-ore reserves of the United States, among which are the following:

1. The steady accretion to the permanent supply of metal and the consequent reduction in rate of increase of production (waste of war not taken into consideration).
2. The adoption of methods of conservation of ore and metal.
3. The increase in imports of ore from Cuba and South America, whose deposits must logically be regarded as a portion of the immediately available reserve, as such ores can be used most profitably and economically in the United States.
4. The further discovery of deposits of iron ore in the Western Hemisphere.
5. Metallurgic improvements that may make it possible to produce pig iron economically from low-grade ores, and the solution of metallurgic problems, including that involving the utilization of titaniferous iron ores, of which there are large deposits not now available for the production of iron.
6. The increase in the price of pig iron, which will bring lower grades of iron ore into the market, thus vastly increasing the available reserves.

Field work by the United States Geological Survey in cooperation with the Minnesota Geological Survey on the iron-ore deposits of the Cuyuna iron-ore district was continued throughout 1916 by E. C. Harder and A. W. Johnston, with the result that a brief report has been issued by the Federal Survey as Bulletin 660–A, and the State Survey has a manuscript in process of publication for a more detailed preliminary bulletin. Mr. Harder has also contributed special papers on the manganiferous iron ores of the Cuyuna district to the United States Geological Survey [1] and to the American Institute of Mining Engineers.[2]

A revised bibliography of Federal and State Survey publications on iron ores is given on pages 559–564.

[1] Harder, E. C., Our mineral supplies—Manganiferous ores: U. S. Geol. Survey Bull. 666–EE, 1917.
[2] Harder, E. C., Manganiferous iron ores of the Cuyuna district: Am. Inst. Min. Eng. Bull. 129, pp. 1313–1344, September, 1917.

# IRON ORE.

## IRON ORE MINED AND SHIPPED IN 1916.

The iron ore, exclusive of that containing 5 per cent or more of manganese,[1] mined in the United States in 1916 amounted to 75,167,672 gross tons, as compared with 55,526,490 gross tons mined in 1915, an increase of 19,641,182 gross tons, or 35 per cent. Beneficiated ore, instead of crude ore mined, is included, if the ore is treated in any way. The quantity of iron ore shipped from the mines in the United States in 1916 amounted to 77,870,553 gross tons, valued at $181,902,277, as compared with 55,493,100 gross tons, valued at $101,288,984, shipped in 1915. This represents an increase in quantity of 22,377,453 gross tons, or 40 per cent, and in value of $80,613,293, or 80 per cent. The average price of ore per ton for the whole country in 1916 was $2.34, as compared with $1.83 in 1915. These quantities of ore, both mined and shipped, include the iron ore used for fluxing other metallic ores at smelters in the Western States, but the shipments do not include the iron ore sold for the manufacture of paint. The quantity of iron ore sold for the manufacture of paint in 1916 amounted to 16,968 gross tons, valued at $45,256, or $2.67 per ton. In Arkansas one producer shipped 5 tons of loadstone, averaging 70.5 per cent of metallic iron, which was sold at a high price to manufacturing druggists. This shipment is not included in the tabulated statistics of iron ore. The ore reported as sold for fluxing other than in the manufacture of pig iron amounted to 88,601 gross tons, valued at $288,089, in 1916, as compared with 17,213 gross tons, valued at $27,456 in 1915. The domestic iron ore actually sold for the manufacture of pig iron amounted in 1916 to 77,781,952 gross tons, valued at $181,614,188, as compared with 55,475,887 gross tons, valued at $101,261,528, in 1915.

A graphic comparison of the annual production of iron ore and its derived metals since 1870 is afforded by the curves shown in figure 5. It must be borne in mind, however, that the figures for the three products are not strictly comparable, because considerable foreign iron ore and also some cinder, scale, and scrap enter into the production of pig iron, and a considerable quantity of scrap iron and steel, as well as cinder and scale, enters into the production of new steel.

### IRON ORE MINED AND SHIPPED, BY STATES.

Iron ore was mined in 24 States in 1916, as compared with 23 States in 1915, Idaho having dropped out and Iowa and West Virginia having been added as producers in 1916. Of these States, Nevada and Utah produced ores for fluxing only; part of the production of Colorado and New Mexico was for smelter flux and part for pig iron and ferroalloys. Michigan and Minnesota report some ore used in open-hearth steel furnaces to "reduce carbon," and North Carolina reports magnetite ore used in puddling furnaces at Knoxville, Tenn. The remaining States produced iron ore for blast-furnace use only, except small quantities for paint from Michigan,

[1] The production of manganiferous iron ore is stated in the chapter on manganese and manganiferous ores in 1916, elsewhere in this volume.

New York, and Wisconsin. The rank of the three States producing the largest quantity of iron ore—Minnesota, Michigan, Alabama—remained unchanged in 1916.

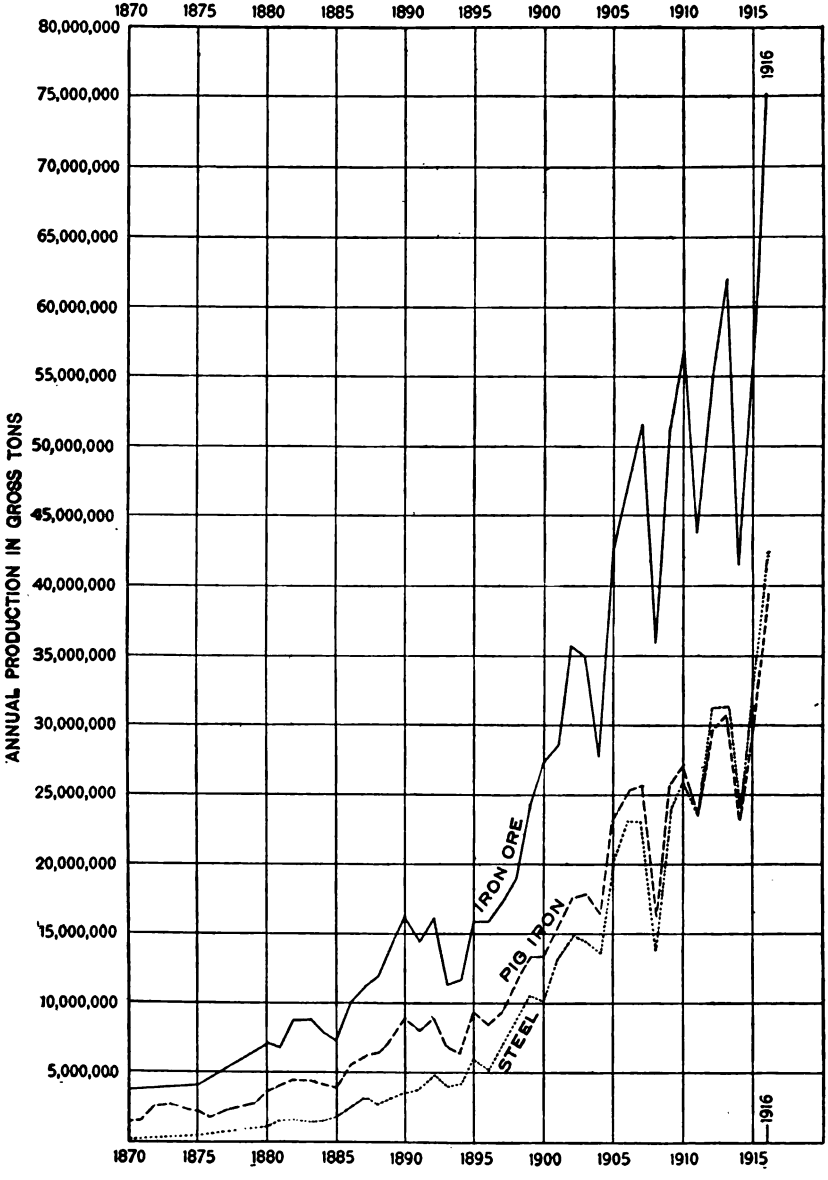


FIGURE 5.—Curves showing annual production of iron ore, pig iron, and steel in the United States, 1870 to 1916.

The Minnesota iron ranges are producing more iron ore than all the rest of the States together, having furnished nearly 60 per cent of the total for the United States in 1916, as well as in 1915. The

Lake Superior district, comprising all the mines in Minnesota and Michigan and those in northern Wisconsin, mined 63,735,088 gross tons in 1916, or nearly 85 per cent of the total production, as compared with 46,944,254 gross tons, or 85 per cent, in 1915.

### IRON-ORE SHIPMENTS.

The following table, showing the iron ore shipped from the mines in 1915 and 1916, by States, is given precedence over the table showing the quantity mined because the table of shipments is the only one in which values are recorded:

*Iron ore shipped from mines in the United States, 1915 and 1916, by States.*

| State. | 1915 | | 1916 | | Increase or decrease in 1916. | | Percentage of increase or decrease in 1916. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity. | Value. |
| Alabama | 5,134,955 | $6,798,266 | 6,801,839 | $10,843,231 | + 1,666,884 | +$4,044,965 | + 32 | + 59 |
| California | 646 | 2,584 | 2,970 | 11,880 | + 2,324 | + 9,296 | +360 | +360 |
| Georgia | 101,719 | 186,083 | 252,143 | 413,259 | + 150,424 | + 227,176 | +148 | +122 |
| Maryland | 1,500 | 2,750 | (a) | (a) | (b) | (b) | (b) | (b) |
| Michigan | 13,664,437 | 28,218,627 | 18,995,797 | 49,054,340 | + 5,331,360 | +20,835,713 | + 39 | + 74 |
| Minnesota | 32,545,236 | 57,742,643 | 45,869,251 | 106,628,784 | +13,324,015 | +48,886,141 | + 41 | + 85 |
| Missouri | 40,290 | 99,853 | 34,914 | 116,484 | − 5,376 | + 16,631 | − 13 | + 17 |
| New Jersey | 391,115 | 1,140,400 | 528,084 | 1,877,056 | + 136,969 | + 736,656 | + 35 | + 65 |
| New Mexico | 34,806 | 54,197 | 157,779 | 168,157 | + 122,973 | + 113,960 | +353 | +210 |
| New York | 931,745 | 2,797,270 | 1,464,917 | 5,571,429 | + 533,172 | + 2,774,159 | + 57 | + 99 |
| Ohio | 3,502 | 8,535 | (a) | (a) | (b) | (b) | (b) | (b) |
| Pennsylvania | 367,056 | 333,697 | 558,556 | 702,633 | + 191,500 | + 368,936 | + 52 | +111 |
| Tennessee | 283,841 | 408,204 | 467,741 | 736,397 | + 183,900 | + 328,193 | + 65 | + 80 |
| Virginia | 334,424 | 696,920 | 486,798 | 1,000,118 | + 152,374 | + 303,198 | + 46 | + 44 |
| Wisconsin | 1,125,269 | 2,188,012 | 1,529,459 | 3,644,542 | + 404,190 | + 1,456,530 | + 36 | + 67 |
| Other States c | 532,559 | 610,943 | 720,305 | 1,133,967 | + b 182,744 | + b 511,739 | +b34 | +b82 |
| | 55,493,100 | 101,288,984 | 77,870,553 | 181,902,277 | +22,377,453 | +80,613,293 | + 40 | + 80 |

a Less than three shippers in Maryland and Ohio in 1916 and permission not granted to publish State totals. Figures for these States, therefore, included in "Other States."

b Increase for Maryland and decrease for Ohio included with those for "Other States."

c 1915: Colorado, Connecticut, Idaho, Massachusetts, Nevada, North Carolina, Utah, and Wyoming; 1916: Colorado, Connecticut, Iowa, Maryland, Massachusetts, Nevada, North Carolina, Ohio, Utah, West Virginia, and Wyoming.

### IRON ORE MINED BY VARIETIES, BY STATES, AND BY MINING DISTRICTS.

Iron minerals comprise sulphides, oxides, carbonates, silicates, and phosphates, of which only the oxides and the carbonates are used in the iron and steel industry, except a very small quantity of oxide by-product from sulphide ores used in the manufacture of sulphuric acid. The ores of iron are generally classed under the four heads, hematite, brown ore, magnetite, and carbonate.[1]

Hematite has always been predominant as an ore of iron, and in 1916 it constituted more than 94 per cent of the iron ore mined in the United States. Brown ore and magnetite are far below it in importance, having together furnished in 1916 less than 6 per cent of the total production of iron ore. The production of iron carbonate is insignificant in comparison with that of the other ores; in 1916 it constituted only about 0.002 per cent of the total.

[1] Notes concerning the composition of these types of ores are given on pages 537–541.

*Iron ore mined in the United States in 1915 and 1916, by States and varieties, in gross tons, with percentage of increase or decrease in 1916.*

| State. | Hematite. | Brown ore. | Magnetite. | Carbonate. | Total quantity. | Percentage of increase or decrease in 1916. |
|---|---|---|---|---|---|---|
| **1915.** | | | | | | |
| Alabama | 4,374,309 | 935,045 | ..... | ..... | 5,309,354 | ..... |
| California | ..... | ..... | 646 | ..... | 646 | ..... |
| Georgia | 16,505 | 99,196 | ..... | ..... | 115,701 | ..... |
| Maryland | ..... | 5,500 | ..... | ..... | 5,500 | ..... |
| Massachusetts | ..... | 3,950 | ..... | ..... | 3,950 | ..... |
| Michigan | 12,514,516 | ..... | ..... | ..... | 12,514,516 | ..... |
| Minnesota | 33,464,660 | ..... | ..... | ..... | 33,464,660 | ..... |
| Missouri | 35,145 | 5,145 | ..... | ..... | 40,290 | ..... |
| Nevada | ..... | 3,993 | ..... | ..... | 3,993 | ..... |
| New Jersey | ..... | ..... | 415,234 | ..... | 415,234 | ..... |
| New Mexico | ..... | ..... | 34,806 | ..... | 34,806 | ..... |
| New York | [a] 71,207 | (a) | 927,638 | ..... | 998,845 | ..... |
| North Carolina | ..... | 857 | 65,596 | ..... | 66,453 | ..... |
| Ohio | ..... | ..... | ..... | 3,455 | 3,455 | ..... |
| Pennsylvania | (b) | [b] 22,552 | 340,757 | ..... | 363,309 | ..... |
| Tennessee | 181,509 | 100,469 | 2,207 | ..... | 284,185 | ..... |
| Virginia | 38,506 | [c] 309,536 | (c) | ..... | 348,042 | ..... |
| Wisconsin | 1,095,388 | ..... | ..... | ..... | 1,095,388 | ..... |
| Wyoming | 434,513 | ..... | ..... | ..... | 434,513 | ..... |
| Other States [d] | ..... | [c] 23,650 | (c) | ..... | 23,650 | ..... |
| | 52,227,324 | 1,488,709 | 1,807,002 | 3,455 | 55,526,490 | ..... |
| **1916.** | | | | | | |
| Alabama | 5,672,005 | 1,075,896 | ..... | ..... | 6,747,901 | + 27 |
| California | ..... | ..... | 3,000 | ..... | 3,000 | + 364 |
| Georgia | 110,647 | 146,302 | ..... | ..... | 256,949 | + 122 |
| Iowa | ..... | 11,351 | ..... | ..... | 11,351 | ..... |
| Maryland | ..... | 4,455 | ..... | ..... | 4,455 | − 19 |
| Michigan | 18,071,016 | ..... | ..... | ..... | 18,071,016 | + 44 |
| Minnesota | 44,585,422 | ..... | ..... | ..... | 44,585,422 | + 33 |
| Missouri | 27,568 | 7,346 | ..... | ..... | 34,914 | − 13 |
| Nevada | ..... | 9,910 | ..... | ..... | 9,910 | + 148 |
| New Jersey | ..... | ..... | 493,004 | ..... | 493,004 | + 19 |
| New Mexico | ..... | ..... | 157,779 | ..... | 157,779 | + 353 |
| New York | 74,723 | (c) | [e] 1,267,784 | ..... | 1,342,507 | + 34 |
| North Carolina | ..... | 4,263 | 60,043 | ..... | 64,306 | − 3 |
| Ohio | ..... | ..... | ..... | 1,800 | 1,800 | − 92 |
| Pennsylvania | ..... | 16,031 | 543,400 | ..... | 559,431 | + 54 |
| Tennessee | 256,093 | 192,541 | 7,200 | ..... | 455,834 | + 60 |
| Utah | ..... | 45,514 | ..... | ..... | 45,514 | (f) |
| Virginia | 80,258 | [c] 360,234 | (c) | ..... | 440,492 | + 27 |
| West Virginia | ..... | 3,605 | ..... | ..... | 3,605 | ..... |
| Wisconsin | 1,304,518 | ..... | ..... | ..... | 1,304,518 | + 19 |
| Wyoming | 545,774 | ..... | ..... | ..... | 545,774 | + 26 |
| Other States [g] | ..... | 28,190 | ..... | ..... | 28,190 | +[f] 167 |
| | 70,728,024 | 1,904,484 | 2,533,364 | 1,800 | 75,167,672 | + 35 |

[a] Brown ore included in hematite.
[b] Hematite included in brown ore.
[c] Magnetite included in brown ore.
[d] Colorado, Connecticut, Idaho, and Utah.
[e] Brown ore included in magnetite.
[f] Less than three producers in Massachusetts in 1916 and in Utah in 1915, and permission not granted to publish State totals. Increases in 1916, therefore, included in "Other States."
[g] Colorado, Connecticut, and Massachusetts.

The principal iron-mining districts in the United States, except the Adirondack and the Birmingham districts, are interstate, and statistics of production by districts are of more general interest and importance than statistics by States. The Lake Superior district mined nearly 85 per cent of the total ore in 1916 and the Birmingham district about 8 per cent, or a little less than one-tenth as much as the Lake district. None of the other individual districts, except the Adirondack, mined as much as 1,000,000 tons. The increase in production in 1916 was especially marked in the Adirondack and the Chattanooga districts, which showed increases, respectively, of 54 and 55 per cent. The production in 1916 of these districts was, however, not greatly different from their normal production as shown by statistics for the years 1912 and 1913; but for the Lake

Superior district to show an increase of 36 per cent in 1916, after having shown a 40 per cent increase in 1915, is a better indication of the response of the large iron mines to the stimulus of war demands.

*Iron ore mined in the United States, by mining districts and varieties, in 1915 and 1916, in gross tons.*

1915.

| District. | Hematite. | Brown ore. | Magnetite. | Carbonate. | Total. |
|---|---|---|---|---|---|
| Lake Superior [a] | 46,944,254 | ..... | ..... | ..... | 46,944,254 |
| Birmingham | 4,213,597 | 535,332 | ..... | ..... | 4,748,929 |
| Chattanooga | 340,481 | 198,543 | ..... | ..... | 539,024 |
| Adirondack | ..... | ..... | 699,213 | ..... | 699,213 |
| Northern New Jersey and southeastern New York | ..... | (b) | [b] 644,493 | ..... | 644,493 |
| Other districts | 728,992 | 754,000 | 464,130 | 3,455 | 1,950,577 |
| | 52,227,324 | 1,488,709 | 1,807,002 | 3,455 | 55,526,490 |

1916.

| District. | Hematite. | Brown ore. | Magnetite. | Carbonate. | Total. | Percentage of increase in 1916. |
|---|---|---|---|---|---|---|
| Lake Superior [a] | 63,735,088 | ..... | ..... | ..... | 63,735,088 | 36 |
| Birmingham | 5,461,444 | 514,574 | ..... | ..... | 5,976,018 | 26 |
| Chattanooga | 540,405 | 296,218 | ..... | ..... | 836,623 | 55 |
| Adirondack | ..... | ..... | 1,077,638 | ..... | 1,077,638 | 54 |
| Northern New Jersey and southeastern New York | ..... | (b) | [b] 683,150 | ..... | 683,150 | 6 |
| Other districts | 991,087 | 1,093,346 | 772,922 | 1,800 | 2,859,155 | 47 |
| | 70,728,024 | 1,904,484 | 2,533,364 | 1,800 | 75,167,672 | 35 |

[a] Includes only those mines in Wisconsin which are in the true Lake Superior district.
[b] Brown ore included in magnetite.

These tables show that the greater part of the hematite comes from the Lake Superior district (Michigan, Minnesota, and Wisconsin) and Alabama, the bulk of the brown ore from the Appalachian States, and the magnetite from New York, Pennsylvania, and New Jersey. The iron carbonate is mined in Ohio. On a later page is given the production of the principal ranges in the Lake Superior district. The bulk of the Lake Superior hematite is more or less hydrated and many deposits include masses of brown ore having varying percentages of combined water. There is, however, a complete gradation from anhydrous hematite to limonite, and as there is no sharp dividing line and as also the greater part of the ore is nearer the anhydrous than the completely hydrated condition, the production of the hydrated ores is included in the production of hematite. Certain mines in northern Michigan produce an ore which is locally termed magnetite. It is a coarsely crystalline anhydrous ore, consisting dominantly of hematite, but having sufficient quantities of magnetite distributed through it to render the ore strongly magnetic. This magnetic ore is also included with hematite in the tables of production, both because it is not a true magnetite and because the quantity is not of sufficient importance to warrant making additional tables for magnetic ores.

The output of the magnetite mines in northern New Jersey and southeastern New York showed an increase of 6 per cent in 1916, the quantity of iron ore mined in the other (unspecified) districts showed a net increase of 47 per cent.

## TOTAL OUTPUT OF IRON ORE.

The following table shows the production of various types of iron ore in the United States as far as it has been recorded or estimated. The statistics from 1889 to the present were collected by the United States Geological Survey; those for 1880 were collected for the census report of that year; those for 1881 were estimated by I. L. Bell;[1] and those from 1882 to 1888, inclusive, were estimated by James M. Swank [2] from the pig iron produced. Figures are not available for the production of various classes of iron ores prior to 1889, except for the census year 1880. The figures for the years prior to 1880 were calculated from the pig iron produced, which included imported ore as well as domestic ore used.

*Iron ore mined in the United States, 1810–1916, in gross tons.*

| Year. | Hematite. | Brown ore. | Magnetite. | Carbonate. | Total. |
|---|---|---|---|---|---|
| 1810–1869 | | | | | 49,656,000 |
| 1870 a–1879 | | | | | 44,570,527 |
| 1880 | 2,243,993 | 1,918,622 | 2,134,276 | 823,471 | 7,120,362 |
| 1881 | | | | | 7,119,643 |
| 1882 | | | | | 8,700,000 |
| 1883 | | | | | 8,800,000 |
| 1884 | | | | | 7,718,129 |
| 1885 | | | | | 7,600,000 |
| 1886 | | | | | 10,000,000 |
| 1887 | | | | | 11,300,000 |
| 1888 | | | | | 12,062,530 |
| 1889 | 9,056,288 | 2,523,087 | 2,506,415 | 432,251 | 14,518,041 |
| 1890 | 10,527,650 | 2,559,938 | 2,570,838 | 377,617 | 16,036,043 |
| 1891 | 9,327,398 | 2,757,564 | 2,317,108 | 189,108 | 14,591,178 |
| 1892 | 11,646,619 | 2,485,101 | 1,971,965 | 192,981 | 16,296,666 |
| 1893 | 8,272,637 | 1,849,272 | 1,330,886 | 134,834 | 11,587,629 |
| 1894 | 9,347,434 | 1,472,748 | 972,219 | 87,278 | 11,879,679 |
| 1895 | 12,513,995 | 2,102,358 | 1,268,222 | 73,039 | 15,957,614 |
| 1896 | 12,576,288 | 2,126,312 | 1,211,526 | 91,423 | 16,005,449 |
| 1897 | 14,413,318 | 1,961,954 | 1,059,479 | 83,295 | 17,518,046 |
| 1898 | 16,150,684 | 1,989,681 | 1,237,978 | 55,373 | 19,433,716 |
| 1899 | 20,004,399 | 2,869,785 | 1,727,430 | 81,559 | 24,683,173 |
| 1900 | 22,708,274 | 3,231,089 | 1,537,551 | 76,247 | 27,553,161 |
| 1901 | 24,006,025 | 3,016,715 | 1,813,076 | 51,663 | 28,887,479 |
| 1902 | 30,532,149 | 3,305,484 | 1,688,860 | 27,642 | 35,554,135 |
| 1903 | 30,328,654 | 3,080,399 | 1,575,422 | 34,833 | 35,019,308 |
| 1904 | 23,839,477 | 2,146,795 | 1,638,846 | 19,212 | 27,644,330 |
| 1905 | 37,567,055 | 2,546,662 | 2,390,417 | 21,999 | 42,526,133 |
| 1906 | 42,481,375 | 2,781,063 | 2,469,294 | 17,996 | 47,749,728 |
| 1907 | 46,060,486 | 2,957,477 | 2,679,067 | 23,589 | 51,720,619 |
| 1908 | 31,788,564 | b 2,620,390 | b 1,547,797 | 26,585 | 35,983,336 |
| 1909 | 46,208,640 | b 2,839,265 | b 2,229,839 | 16,527 | 51,294,271 |
| 1910 | 51,367,007 | b 2,993,744 | b 2,631,835 | 22,320 | 57,014,906 |
| 1911 | 39,626,224 | 2,032,094 | 2,202,527 | 15,707 | 43,876,552 |
| 1912 | 51,345,782 | 1,614,486 | 2,179,533 | 10,346 | 55,150,147 |
| 1913 | 57,933,251 | 1,682,063 | 2,357,274 | 7,849 | 61,980,437 |
| 1914 | 38,286,670 | 1,537,750 | 1,610,203 | 5,138 | 41,439,761 |
| 1915 | 52,227,224 | 1,488,709 | 1,807,002 | 3,455 | 55,526,490 |
| 1916 | 70,728,024 | 1,904,484 | 2,533,364 | 1,800 | 75,167,672 |
| | | | | | 1,127,242,890 |

a Includes ore produced by owners of blast furnaces, estimated by census at 800,000 tons.
b Some brown ore included in magnetite.

## PRINCIPAL IRON-ORE MINES.

In 1916 there were 405 iron-ore mines active, compared with 340 in 1915, and 222 mines in 1916 produced more than 50,000 gross tons of iron ore each, compared with 184 mines in 1915. Of these 222 mines, 12 produced more than 1,000,000 tons of iron ore each in 1916, 5 more than in 1915. First place in 1916 was held by the Hull-Rust mine, at Hibbing, Minn.; second place by the Red Moun-

[1] Principles of the manufacture of iron and steel, p. 451, 1884.
[2] U. S. Geol. Survey Mineral Resources, 1882 to 1888.

tain group, near Bessemer, Ala.; third place by the Fayal, at Eveleth, Minn.; and fourth place by the Mahoning, at Hibbing, Minn. The production of these mines in 1916 was, respectively, 7,658,201 tons, 2,899,588 tons, 2,252,008 tons, and 2,215,788 tons, in 1916, compared with 2,307,195 tons, 2,138,015 tons, 871,364 tons, and 2,311,940 tons, respectively, in 1915. The Mahoning was the largest producer in 1915. The increase in production of the Fayal is noteworthy—more than 158 per cent. Eight of the 12 mines producing more than 1,000,000 tons in 1916 are in Minnesota. The largest producer in Michigan in 1916 was the Norrie group, which reported having mined 1,566,566 gross tons of hematite, a considerable increase over the production in 1915, which was 897,484 tons. Permission has been granted to the Survey by the owners and operators of 201 of these large mines to publish their production, and these statistics are given in the following table:

*Iron ore mines of the United States that produced more than 50,000 gross tons each in 1916.*

| Rank. | Mine. | State. | Nearest town. | Variety of ore. | Quantity mined. |
|---|---|---|---|---|---|
| | | | | | *Gross tons.* |
| 1 | Hull-Rust | Minnesota | Hibbing | Hematite | 7,658,201 |
| 2 | Red Mountain group | Alabama | Bessemer | do | 2,899,588 |
| 3 | Fayal | Minnesota | Eveleth | do | 2,252,008 |
| 4 | Mahoning | do | Hibbing | do | 2,215,788 |
| 5 | Canisteo | do | Coleraine | do | 1,943,745 |
| 6 | Morris | do | Hibbing | do | 1,609,971 |
| 7 | Norrie group | Michigan | Ironwood | do | 1,566,566 |
| 8 | Sellers | Minnesota | Hibbing | do | 1,344,121 |
| 9 | Leonidas | do | Eveleth | do | 1,098,669 |
| 10 | Wakefield | Michigan | Wakefield | do | 1,092,737 |
| 11 | Burt | Minnesota | Hibbing | do | 1,058,277 |
| 12 | Newport and Bonnie | Michigan | Ironwood | do | 1,014,742 |
| 13 | Adams | Minnesota | Eveleth | do | 961,500 |
| 14 | Shenango | do | Chisholm | do | 940,660 |
| 15 | Sauntry-Alpena | do | Virginia | do | 890,999 |
| 16 | Woodward Nos. 1, 2, and 3 | Alabama | Liscomb | do | 833,308 |
| 17 | Witherbee, Sherman & Co (Inc.). | New York | Mineville | Magnetite | 750,817 |
| 18 | Susquehanna | Minnesota | Hibbing | Hematite | 742,098 |
| 19 | Dean | do | Buhl | do | 687,878 |
| 20 | Bennett | do | Keewatin | do | 651,402 |
| 21 | Leetonia | do | Hibbing | do | 622,530 |
| 22 | Holman | do | Taconite | do | 610,281 |
| 23 | Hawkins | do | Nashwauk | do | 603,437 |
| 24 | Commodore | do | Virginia | do | 579,285 |
| 25 | Hill | do | Marble | do | 552,136 |
| 26 | Missabe Mountain | do | Virginia | do | 539,913 |
| 27 | Kerr | do | Hibbing | do | 539,675 |
| 28 | Sunrise | Wyoming | Sunrise | do | 521,627 |
| 29 | Chapin | Michigan | Iron Mountain | do | 516,135 |
| 30 | Cornwall | Pennsylvania | Miners Village | Magnetite | 495,437 |
| 31 | Palms | Michigan | Bessemer | Hematite | 485,725 |
| 32 | Leonard-Burt | Minnesota | Chisholm | do | 482,580 |
| 33 | Pioneer | do | Ely | do | 472,728 |
| 34 | Albany | do | Hibbing | do | 468,592 |
| 35 | Kinney | do | Kinney | do | 466,576 |
| 36 | Zenith | do | Ely | do | 463,819 |
| 37 | Montreal | Wisconsin | Montreal | do | 462,599 |
| 38 | Bristol | Michigan | Crystal Falls | do | 455,700 |
| 39 | North Harrison | Minnesota | Nashwauk | do | 434,584 |
| 40 | Colby | Michigan | Bessemer | do | 430,000 |
| 41 | Biwabik | Minnesota | Biwabik | do | 428,943 |
| 42 | Caspian | Michigan | Palatka | do | 421,962 |
| 43 | Leonard | Minnesota | Chisholm | do | 417,351 |
| 44 | Spruce | do | Eveleth | do | 398,354 |
| 45 | Helmer | do | Kinney | do | 395,615 |
| 46 | Ordean | do | Virginia | do | 395,591 |
| 47 | Penn group | Michigan | Vulcan and Norway | do | 375,806 |
| 48 | Utica | Minnesota | Hibbing | do | 331,943 |
| 49 | Plymouth | Michigan | Verona | do | 330,427 |
| 50 | Stevenson | Minnesota | Hibbing | do | 330,120 |
| 51 | Armour No. 2 | do | Crosby | do | 327,023 |
| 52 | Puritan | Michigan | Ironwood | do | 318,103 |
| 53 | Mace No. 2 | Minnesota | Nashwauk | do | 307,443 |
| 54 | Corsica | do | Gilbert | do | 306,620 |
| 55 | Tully | Michigan | Stambaugh | do | 294,600 |

*Iron ore mines of the United States that produced more than 50,000 gross tons each in 1916*—Continued.

| Rank. | Mine. | State. | Nearest town. | Variety of ore. | Quantity mined. |
|---|---|---|---|---|---|
| | | | | | *Gross tons.* |
| 56 | Carpenter | Michigan | Crystal Falls | Hematite | 288,211 |
| 57 | Itasca | Minnesota | Buhl | do | 275,108 |
| 58 | Queen group | Michigan | Negaunee | do | 273,469 |
| 59 | Lake Superior | do | Ishpeming | do | 271,113 |
| 60 | Kevin | Minnesota | Nashwauk | do | 265,868 |
| 61 | Genoa | do | Gilbert | do | 265,465 |
| 62 | La Rue | do | Nashwauk | do | 263,868 |
| 63 | Chisholm | do | Chisholm | do | 259,381 |
| 64 | Miller | do | Aurora | do | 251,854 |
| 65 | Woodbridge | do | Buhl | do | 249,907 |
| 66 | Baltic (including Fogarty) | Michigan | Palatka | do | 249,782 |
| 67 | Songo | Alabama | Songo | do | 248,953 |
| 68 | Balkan | Michigan | Alpha | do | 247,583 |
| 69 | Union | Minnesota | Virginia | do | 245,029 |
| 70 | Glen | do | Chisholm | do | 243,859 |
| 71 | Raimund No. 1 | Alabama | Bessemer | do | 241,564 |
| 72 | Clark | Minnesota | Chisholm | do | 237,193 |
| 73 | Cary | Wisconsin | Hurley | do | 236,045 |
| 74 | Aragon | Michigan | Norway | do | 225,535 |
| 75 | Pewabic | do | Iron Mountain | do | 224,674 |
| 76 | Tobin | do | Crystal Falls | do | 223,900 |
| 77 | Mary Charlotte, Nos. 1 and 2 | do | Negaunee | do | 223,758 |
| 78 | Chatham | do | Stambaugh | do | 222,249 |
| 79 | Lincoln | Minnesota | Virginia | do | 218,413 |
| 80 | Aurora | Michigan | Ironwood | do | 217,674 |
| 81 | Quinn | Minnesota | Nashwauk | do | 217,630 |
| 82 | Mount Hope | New Jersey | Mount Hope | Magnetite | 215,184 |
| 83 | Graham | Minnesota | Mesaba | Hematite | 211,931 |
| 84 | Ottawa | Wisconsin | Montreal | do | 211,668 |
| 85 | Homer | Michigan | Iron River | do | 210,332 |
| 86 | Kennedy | Minnesota | Cuyuna | do | 209,777 |
| 87 | Sibley | do | Ely | do | 207,761 |
| 88 | Mohawk | do | Aurora | do | 207,564 |
| 89 | Pennington | do | Ironton | do | 206,085 |
| 90 | Brunt | do | Mountain Iron | do | 204,982 |
| 91 | Rolling Mill | Michigan | Negaunee | do | 201,242 |
| 92 | Cambria | do | do | do | 200,452 |
| 93 | Judson | do | Alpha | do | 200,168 |
| 94 | Thompson | Minnesota | Crosby | do | 197,157 |
| 95 | Bengal | Michigan | Palatka | do | 197,094 |
| 96 | Section 30 | Minnesota | Ely | do | 192,559 |
| 97 | Pettit | do | Gilbert | do | 189,384 |
| 98 | Richmond | Michigan | Palmer | do | 182,041 |
| 99 | Eureka | do | Ramsay | do | 181,719 |
| 100 | Webb | Minnesota | Hibbing | do | 181,378 |
| 101 | Zimmerman | Michigan | Gaastra | do | 181,000 |
| 102 | Norman | Minnesota | Virginia | do | 180,529 |
| 103 | Brown Mining Co | Tennessee | Cardiff | do | 175,687 |
| 104 | Ironton | Michigan | Bessemer | do | 175,500 |
| 105 | Rowe | Minnesota | Riverton | do | 174,002 |
| 106 | Sliver | do | Virginia | do | 173,963 |
| 107 | Steinman | Alabama | Steinman | do | 172,800 |
| 108 | Hiawatha | Michigan | Iron River | do | 171,692 |
| 109 | Laura | Minnesota | Hibbing | do | 166,967 |
| 110 | Rogers | Michigan | Iron River | do | 164,196 |
| 111 | Harold | Minnesota | Hibbing | do | 159,125 |
| 112 | American-Boston | Michigan | Diorite | do | 154,559 |
| 113 | Greeley | Alabama | Greeley | Brown ore | 151,927 |
| 114 | Shiras | Minnesota | Buhl | Hematite | 144,913 |
| 115 | Chicagon | Michigan | Iron River | do | 139,223 |
| 116 | Soudan | Minnesota | Soudan | do | 138,251 |
| 117 | Bangor | do | Biwabik | do | 137,988 |
| 118 | Belgrade | do | do | do | 136,988 |
| 119 | Wanless | do | Buhl | do | 136,661 |
| 120 | Spaulding | Alabama | Birmingham | do | 134,289 |
| 121 | Elba | Minnesota | Gilbert | do | 133,217 |
| 122 | Sunday Lake | Michigan | Wakefield | do | 131,409 |
| 123 | Mayville | Wisconsin | Mayville | do | 130,868 |
| 124 | Loretto | Michigan | Loretto | do | 129,696 |
| 125 | Osana | do | Iron River | do | 127,943 |
| 126 | North Eddy | Minnesota | Hibbing | do | 126,974 |
| 127 | Mace, No. 1 | do | do | do | 126,264 |
| 128 | Ernst mine | Wisconsin | Commonwealth | do | 125,699 |
| 129 | Forbes | Michigan | Iron River | do | 124,424 |
| 130 | Attalla | Alabama | Attalla | do | 117,456 |
| 131 | South Chandler | Minnesota | Ely | do | 117,302 |
| 132 | Clifford | Michigan | Iron Mountain | do | 115,691 |
| 133 | North Anvil | do | Bessemer | do | 115,280 |
| 134 | Ironaton | Alabama | Ironaton | Brown ore | 111,416 |
| 135 | Grant | Minnesota | Buhl | Hematite | 110,604 |
| 136 | Breitung-Hematite, No. 2 | Michigan | Negaunee | do | 110,520 |

*Iron ore mines of the United States that produced more than 50,000 gross tons each in 1916*—Continued.

| Rank. | Mine. | State. | Nearest town. | Variety of ore. | Quantity mined. |
|---|---|---|---|---|---|
| | | | | | *Gross tons.* |
| 137 | Tilden | Michigan | Bessemer | Hematite | 110,507 |
| 138 | Weed | Minnesota | Mesaba | do | 108,529 |
| 139 | Brotherton | Michigan | Wakefield | do | 107,914 |
| 140 | Hudson | Minnesota | Aurora | do | 105,033 |
| 141 | Mahnomen | do | Ironton | do | 105,000 |
| 142 | Agnew | do | Hibbing | do | 102,350 |
| 143 | Chester | do | Chisholm | do | 101,256 |
| 144 | Deacon | do | Buhl | do | 99,435 |
| 145 | Cahoon | Wisconsin | Baraboo | do | 95,000 |
| 146 | Philbin | Minnesota | Hibbing | do | 94,512 |
| 147 | Washington | New Jersey | Oxford Furnace | Magnetite | 94,379 |
| 148 | Wacoutah | Minnesota | Mountain Iron | Hematite | 93,730 |
| 149 | Asteroid | Michigan | Ramsay | do | 92,753 |
| 150 | Castile | do | Wakefield | do | 92,081 |
| 151 | Geneva | do | Ironwood | do | 91,876 |
| 152 | Bates | do | Iron River | do | 90,595 |
| 153 | Hanna B | Minnesota | Mountain Iron | do | 88,089 |
| 154 | Raimund, No. 2 | Alabama | Bessemer | do | 86,965 |
| 155 | Croft | Minnesota | Crosby | do | 85,033 |
| 156 | Davidson, No. 1 | Michigan | Iron River | do | 84,288 |
| 157 | Riverton group | do | do | do | 84,087 |
| 158 | Isabella | do | Palmer | do | 83,113 |
| 159 | Youngs | do | Palatka | do | 82,935 |
| 160 | Minnewas | Minnesota | Virginia | do | 81,967 |
| 161 | Victoria | do | do | do | 80,434 |
| 162 | Breitung-Hematite, No. 1 | Michigan | Negaunee | do | 80,175 |
| 163 | Oriskany | Virginia | Oriskany | Brown ore | 80,100 |
| 164 | Houston | Alabama | Rickey | do | 79,307 |
| 165 | Perkins | Minnesota | Aurora | Hematite | 79,275 |
| 166 | Armour, No. 1 | do | Crosby | do | 76,799 |
| 167 | Ashland | Michigan | Ironwood | do | 76,707 |
| 168 | Chandler | Minnesota | Ely | do | 76,377 |
| 169 | Amasa-Porter | Michigan | Amasa | do | 76,335 |
| 170 | Davidson, No. 2 | do | Iron River | do | 75,066 |
| 171 | Yale | do | Bessemer | do | 73,824 |
| 172 | Himrod | do | Negaunee | do | 72,593 |
| 173 | Docray | Alabama | Docray | Brown ore | 71,996 |
| 174 | Raimund, No. 3 | do | Bessemer | Hematite | 68,295 |
| 175 | Odgers | Michigan | Crystal Falls | do | 66,200 |
| 176 | Tannehill | Alabama | Goethite | Brown ore | 65,997 |
| 177 | Saint James | Minnesota | Aurora | Hematite | 64,100 |
| 178 | Wilcox | do | Brainerd | do | 63,907 |
| 179 | Lone Jack | do | Virginia | do | 61,994 |
| 180 | Adriatic | do | Mesaba | do | 61,921 |
| 180 | Volunteer | Michigan | Palmer | do | 61,921 |
| 181 | Ohio | do | Michigamme | do | 61,184 |
| 182 | Alexandria | Minnesota | Chisholm | do | 60,615 |
| 183 | Grace | do | Hibbing | do | 60,459 |
| 184 | Jim Fair | New Mexico | Fierro | Magnetite | 60,506 |
| 185 | Cranberry | North Carolina | Cranberry | do | 60,043 |
| 186 | Thorne | Minnesota | Buhl | Hematite | 59,253 |
| 187 | Cottrell | Michigan | Iron River | do | 58,889 |
| 188 | Franklin | Minnesota | Virginia | do | 58,708 |
| 189 | Empire | Michigan | Palmer | do | 58,520 |
| 190 | Virgil | do | Iron River | do | 57,688 |
| 191 | Myers | Minnesota | Chisholm | do | 57,026 |
| 192 | Meacham | do | Crosby | do | 56,427 |
| 193 | Snow Flake | New Mexico | Fierro | Magnetite | 56,094 |
| 194 | Jordan | Virginia | Jordan | Brown ore | 53,949 |
| 195 | Percy | Tennessee | Riverside | do | 53,059 |
| 196 | Stegmiller | Michigan | Swanzy | Hematite | 52,430 |
| 197 | Morton | Minnesota | Hibbing | do | 51,877 |
| 198 | Valley View, No. 2 | Alabama | Birmingham | do | 51,446 |
| 199 | Judd | Minnesota | Taconite | do | 50,263 |
| 200 | Adams | Michigan | Ishpeming | do | 50,120 |
| | Total (201 mines) | | | | 68,021,227 |
| | Unspecified (21 mines)[a] | | | | 4,595,563 |
| | Tonnage from mines producing more than 50,000 gross tons each. | | | | 72,616,790 |
| | Tonnage from mines producing less than 50,000 gross tons each. | | | | 2,550,882 |
| | Grand total of United States. | | | | 75,167,672 |

[a] Includes the product of 21 mines producing more than 50,000 gross tons each and operated by 10 companies which do not permit the publication of individual figures.

## STOCK OF IRON ORE AT MINES.

According to the reports of producers, a few of which have been revised since the report for 1915 was published, the total quantity of iron ore in stock at the mines at the close of 1916 amounted to 10,876,352 gross tons, compared with 13,584,756 tons at the close of 1915, a decrease of 20 per cent. As the tonnage of ore in stock piles is necessarily partly estimated, there are variations in the mine reports from year to year which prevent an absolute balance between the quantity mined and the quantity sold and stocks on hand.

*Stock of iron ore at mines, by States, Dec. 31, 1915 and 1916, in gross tons.*

| State. | 1915 | 1916 | State. | 1915 | 1916 |
|---|---|---|---|---|---|
| Alabama | 737,937 | 684,199 | New Jersey | 178,284 | 149,227 |
| California | ..... | 30 | New York | 270,193 | 129,986 |
| Georgia | 13,803 | 11,943 | Ohio | 3,388 | 3,388 |
| Iowa | ..... | 1,200 | Pennsylvania | 38,766 | 38,450 |
| Maryland | 9,654 | 1,050 | Tennessee | 30,488 | 18,515 |
| Massachusetts | 2,000 | 4,000 | Virginia | 84,329 | 37,014 |
| Michigan | 5,582,782 | 4,671,032 | Wisconsin | 518,472 | 280,548 |
| Minnesota | 6,109,520 | 4,831,690 | | | |
| Missouri | 5,140 | 5,080 | | 13,584,756 | 10,876,352 |

## PRICES OF IRON ORE PER TON.

In the following table the average price per ton at the mines of the different classes of iron ore in 1915 and 1916 is given for each of the producing States or groups of States, except where there were less than three producers of a certain variety of ore, and permission was not given to publish in a State whose total may be published. The total average prices per gross ton (the whole United States considered) in 1916 were: Hematite, $2.32; brown ore, $2.03; magnetite, $3.11; carbonate, $3, as compared with prices, respectively, of $1.80, $1.80, $2.50, and $2.44, in 1915. These figures are taken directly from statements of the producers and are probably only approximately correct. The element of inaccuracy lies in the fact that by far the greater bulk of the iron ore produced in the United States is mined by iron and steel producers for their own furnaces and that the value placed on such ore is therefore largely a matter of accounting. Some of the reports made to the Survey evidently include merely actual mining costs; others contain, in addition, the cost of selling and insuring the ore; in others an allowance for sinking fund is included; and in still others the figures given are the prices used in charging costs against the blast furnaces. At any rate, they include no freight costs. The selling prices of Lake Superior iron ore at lower Lake ports are given on page 527.

The general average price per gross ton of all kinds of iron ore in the United States was $2.34 in 1916, compared with $1.83 in 1915, an increase of 51 cents a ton, or nearly 28 per cent.

*Average price per gross ton of iron ore shipped from mines in the United States in 1915 and 1916.*

| State. | Hematite. | | Brown ore. | | Magnetite. | | Carbonate. | |
|---|---|---|---|---|---|---|---|---|
| | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 |
| Alabama | $1.25 | $1.52 | $1.68 | $1.97 | | | | |
| California | | | | | $4.00 | $4.00 | | |
| Georgia | 1.53 | 1.32 | 1.88 | 1.87 | | | | |
| Maryland | | | 1.83 | (a) | | | | |
| Michigan | 2.07 | 2.58 | | | | | | |
| Minnesota | 1.77 | 2.32 | | | | | | |
| Missouri | 2.55 | 3.58 | (a) | 2.41 | | | | |
| New Jersey | | | | | 2.92 | 3.55 | | |
| New Mexico | | | | | 1.56 | 1.07 | | |
| New York | (a) | 2.09 | (a) | (a) | 3.08 | 3.88 | | |
| Ohio | | | | | | | $2.44 | b $3.00 |
| Pennsylvania | (a) | | 2.59 | 3.05 | .77 | (a) | | |
| Tennessee | 1.30 | 1.42 | 1.67 | 1.76 | (a) | (a) | | |
| Virginia | 1.91 | 2.06 | 2.04 | 2.05 | (a) | (a) | | |
| Wisconsin | 1.94 | 2.38 | | | | | | |
| Other States c | .97 | 1.00 | 2.87 | 3.04 | 1.60 | 4.00 | | |
| Total average | 1.80 | 2.32 | 1.80 | 2.03 | 2.50 | 3.11 | 2.44 | b 3.00 |

a Less than three producers and permission to publish not given; therefore price may not be shown.
b Estimated.
c 1915: Colorado, Connecticut, Idaho, Massachusetts, Nevada, North Carolina, Utah, and Wyoming; 1916: Colorado, Connecticut, Iowa, Maryland, Massachusetts, Nevada, North Carolina, Utah, West Virginia, and Wyoming.

*Average price per gross ton of iron ore in the United States, 1889 and 1892 to 1916.*

| Year. | Hematite. | Brown ore. | Magnetite. | Carbonate. | General average. |
|---|---|---|---|---|---|
| 1889 | | | | | $2.30 |
| 1892 | | | | | 2.04 |
| 1893 | | | | | 1.66 |
| 1894 | | | | | 1.14 |
| 1895 | | | | | 1.14 |
| 1896 | | | | | 1.42 |
| 1897 | | | | | 1.08 |
| 1898 | | | | | 1.14 |
| 1899 | | | | | 1.42 |
| 1900 | | | | | 2.42 |
| 1901 | | | | | 1.71 |
| 1902 | | | | | 1.84 |
| 1903 | | | | | 1.89 |
| 1904 | | | | | 1.56 |
| 1905 | | | | | 1.77 |
| 1906 | $2.13 | $1.78 | $2.05 | $1.75 | 2.11 |
| 1907 | 2.63 | 1.81 | 2.03 | 1.74 | 2.55 |
| 1908 | 2.32 | 1.70 | 2.40 | 1.38 | 2.27 |
| 1909 | 2.17 | 1.68 | 2.40 | 1.73 | 2.15 |
| 1910 | 2.52 | 1.76 | 2.36 | 1.61 | 2.47 |
| 1911 | 2.12 | 1.72 | 2.29 | 1.83 | 2.11 |
| 1912 | 1.87 | 1.79 | 2.18 | 1.96 | 1.88 |
| 1913 | 2.21 | 1.88 | 2.07 | 2.06 | 2.19 |
| 1914 | 1.79 | 1.72 | 2.39 | 2.44 | 1.81 |
| 1915 | 1.80 | 1.80 | 2.50 | 2.44 | 1.83 |
| 1916 | 2.32 | 2.03 | 3.11 | 3.00 | 2.34 |

## APPARENT CONSUMPTION OF IRON ORE COMPARED WITH PRODUCTION OF PIG IRON.

The following table includes data on certain items from which an approximate estimate of the annual consumption of iron ore in the United States is deduced. The result is, of course, merely an approximation, for no data are available on certain items, such as stocks at furnaces, which should enter into the final result. The items considered in the table and in the annual estimates for all

years preceding 1911 are (1) domestic iron ore mined; (2) stocks of ore at mines; (3) stocks of ore at lower Lake ports; (4) production of zinc residuum; (5) imports of ore; (6) exports of ore. Beginning with 1911 data on the shipments of ore became available, and these figures, together with zinc residuum and imports of ore, constitute the available supply, which, less the exports, gives the apparent consumption, without consideration of the stocks at mines and at Lake ports. This apparent consumption includes small quantities of ore not used in the manufacture of pig iron, such as ore consumed in the open-hearth steel furnaces and in smelting gold, silver, and copper; but it does not include ore used in the manufacture of paint.

In the same table is given the production of pig iron, including ferromanganese, spiegeleisen, ferrosilicon, and other ferroalloys, for corresponding years and the ratio of pig iron and ferroalloys produced to iron ore consumed. On later pages of the report will be found detailed statistics on the production and shipments of pig iron.

The ratio of pig iron manufactured to iron ore consumed was 50.42 per cent in 1916, as compared with 53.15 per cent in 1915. The ratio in 1914, 57.45 per cent, is the highest percentage shown for the last 28 years, except that for 1893, which was apparently 61.33 per cent (but may be inaccurate). The tendency in iron-ore mining to produce ore of higher grade in times of small demand than in years when the maximum output is demanded, is clearly shown in the last column of the table. In the years 1893, 1904, 1908, 1911, and 1914 there were notable decreases in production of iron ore, and in each of these years except 1908 the ratio of pig iron produced to iron ore consumed rose between 2 and 7 per cent. Likewise, in most years in which there was considerable increase in production of iron ore the ratio has decreased, as in 1902, 1905, 1906, 1907, 1912, 1913, 1915, and 1916.

The actual figures of consumption of ore as reported directly to the Survey by the manufacturers of iron are of interest in comparison with the figures in this table. Prior to 1915 such data have not been sufficiently complete for publication, but in connection with the statistics of value of pig iron, which are collected by the Survey alone, it has been found necessary to gather related data, some of which are now sufficiently complete for publication. For instance, the quantity of domestic iron ore consumed in the manufacture of pig iron in 1916, according to reports to the Survey from blast furnaces, was 70,769,337 gross tons; the total consumption of iron ore in 1916, including imported ore and 4,036,022 tons of mill cinder, scale, scrap, etc., was 76,100,877 gross tons, from which were produced 38,701,963 gross tons of pig iron, exclusive of ferroalloys—a ratio of pig iron produced to ore consumed of 50.86 per cent. In 1915 the domestic ore consumed was 53,775,945 gross tons and the total consumption of iron ore, including imported ore and 251,593 tons of mill cinder, scale, scrap, etc., was 55,409,022 gross tons, from which were produced 29,556,944 gross tons of pig iron, exclusive of ferroalloys—a ratio of pig iron produced to ore consumed of 53.34 per cent.

*Apparent consumption of iron ore compared with production of pig iron in the United States, 1889–1916, in gross tons.*

| Year. | Domestic iron ore produced.[a] | Stocks of ore at mines. | Stocks of ore at lower Lake ports Dec. 1. | Zinc residuum. | Imports. | Exports. | Apparent consumption. | Pig iron produced.[b] | Percentage ratio of pig iron to iron ore. |
|---|---|---|---|---|---|---|---|---|---|
| 1889 | 14,518,041 | 2,256,973 | 2,607,106 | 43,648 | 853,573 | ..... | 14,366,562 | 7,603,642 | 52.93 |
| 1890 | 16,036,043 | 2,000,000 | 3,893,487 | 48,560 | 1,246,830 | ..... | 16,302,025 | 9,202,703 | 56.45 |
| 1891 | 14,591,178 | 2,450,279 | 3,508,489 | 38,228 | 912,864 | ..... | 15,476,989 | 8,279,870 | 53.50 |
| 1892 | 16,296,666 | 2,911,740 | 4,149,451 | 31,859 | 806,585 | ..... | 16,032,687 | 9,157,000 | 57.11 |
| 1893 | 11,587,629 | 3,526,161 | 4,070,710 | 37,512 | 526,951 | ..... | 11,616,412 | 7,124,502 | 61.33 |
| 1894 | 11,879,679 | 3,236,198 | 4,834,247 | 26,981 | 167,307 | ..... | 11,600,393 | 6,657,388 | 57.39 |
| 1895 | 15,957,614 | 2,976,494 | 4,415,712 | 43,249 | 524,153 | ..... | 17,203,255 | 9,446,308 | 54.91 |
| 1896 | 16,005,449 | 3,405,302 | 4,954,984 | 44,953 | 682,806 | ..... | 15,765,128 | 8,623,127 | 54.70 |
| 1897 | 17,518,046 | 3,098,287 | 5,923,755 | 33,924 | 489,970 | ..... | 17,380,184 | 9,652,680 | 55.54 |
| 1898 | 19,433,716 | 2,846,457 | 5,136,407 | 48,502 | 187,208 | ..... | 20,708,604 | 11,773,934 | 56.86 |
| 1899 | 24,683,173 | 2,320,278 | 5,530,283 | 65,010 | 674,082 | 40,665 | 25,513,903 | 13,620,703 | 53.39 |
| 1900 | 27,553,161 | 3,709,950 | 5,904,670 | 87,110 | 897,831 | 51,460 | 26,722,583 | 13,789,242 | 51.60 |
| 1901 | 28,887,479 | 4,239,823 | 5,859,663 | 52,311 | 966,950 | 64,703 | 29,357,171 | 15,878,354 | 54.09 |
| 1902 | 35,554,135 | 3,834,717 | 7,074,254 | 65,246 | 1,165,470 | 88,445 | 35,886,921 | 17,821,307 | 49.66 |
| 1903 | 35,019,308 | 6,297,888 | 6,371,085 | 73,264 | 980,440 | 80,611 | 34,232,399 | 18,009,252 | 52.61 |
| 1904 | 27,644,330 | 4,666,931 | 5,763,399 | 68,189 | 487,613 | 213,865 | 30,224,910 | 16,497,033 | 54.58 |
| 1905 | 42,526,133 | 3,812,281 | 6,438,967 | 90,289 | 845,651 | 208,017 | 43,433,138 | 22,992,380 | 52.94 |
| 1906 | 47,749,728 | 3,281,789 | 6,252,455 | 93,461 | 1,060,390 | 265,240 | 49,355,343 | 25,307,191 | 51.28 |
| 1907 | 51,720,619 | 3,033,110 | 7,385,728 | 93,413 | 1,229,168 | 278,608 | 51,879,998 | 25,781,361 | 49.69 |
| 1908 | 35,983,336 | 6,065,397 | 8,441,533 | 110,225 | 776,898 | 309,099 | 32,473,268 | 15,936,018 | 49.74 |
| 1909 | 51,294,271 | 6,135,271 | 8,965,789 | 141,264 | 1,694,957 | 455,934 | 52,080,428 | 25,795,471 | 49.53 |
| 1910 | 57,014,906 | 9,422,285 | 9,426,881 | 137,173 | 2,591,031 | 748,875 | 55,246,129 | 27,303,567 | 49.42 |
| 1911 | 41,092,447 | ..... | ..... | 109,296 | 1,811,732 | 768,386 | 42,245,089 | 23,649,547 | 55.98 |
| 1912 | 57,017,614 | ..... | ..... | 104,670 | 2,104,576 | 1,195,742 | 58,031,118 | 29,726,937 | 51.23 |
| 1913 | 59,643,098 | ..... | ..... | 102,239 | 2,594,770 | 1,042,151 | 61,297,956 | 30,966,152 | 50.52 |
| 1914 | 39,714,280 | ..... | ..... | 100,198 | 1,350,588 | 551,618 | 40,613,448 | 23,332,244 | 57.45 |
| 1915 | 55,493,100 | ..... | ..... | 159,318 | 1,341,281 | 707,641 | 56,286,058 | 29,916,213 | 53.15 |
| 1916 | 77,870,553 | ..... | ..... | 198,817 | 1,325,736 | 1,183,952 | 78,211,154 | 39,434,797 | 50.42 |

[a] Beginning with 1910, iron ore sold for paint excluded from production and included in metallic paint. Beginning with 1911, figures represent shipments.
[b] From annual reports of the American Iron and Steel Association prior to 1912, and including ferroalloys produced in blast furnaces; beginning with 1912, according to American Iron and Steel Institute, and also including ferroalloys.

## IRON-ORE INDUSTRY IN THE LAKE SUPERIOR DISTRICT.

### PRODUCTION.

The Lake Superior district within the United States includes the Vermilion, Mesabi, Cuyuna, Gogebic, Marquette, and Menominee ranges in the States of Minnesota, Michigan, and Wisconsin. The Menominee range includes the Crystal Falls, Metropolitan, Iron River, and Florence areas; the Marquette range includes the Republic and Swanzy areas. The Baraboo and the Iron Ridge areas of southern Wisconsin and the Spring Valley area of northwestern Wisconsin are not properly included in the Lake Superior district. In the first group of ranges the ore mined is almost entirely Algonkian hematite, belonging to the Huronian series. The Baraboo ore is of the same nature, but the Iron Ridge ore is "Clinton" hematite and the Spring Valley ore is brown ore. Ore production was resumed in 1915 in the Baraboo area, developments having been abandoned for several years on account of unsatisfactory quality of ore and too great quantity of underground water. The Cahoon mine in Sauk County mined 95,000 tons in 1916, compared with 50,000 tons in 1915, its first production.

The ranges in the United States which produced ore in 1916 were the Vermilion, Mesabi, Gogebic, Marquette, Menominee, and Cuyuna, besides the Baraboo and Iron Ridge areas. All the ranges in the Lake Superior district mined a larger quantity of iron ore in 1916 than in 1915 the largest increases being in the Menominee and Gogebic ranges—43 and 54 per cent, respectively. The output of the Cuyuna range exceeded 1,500,000 tons for the first time.

The total quantity of ore mined from the Lake Superior district, excluding the Baraboo and Iron Ridge areas, in 1916, was 63,735,088 gross tons, compared with 46,944,254 gross tons in 1915, an increase of 16,790,834 tons, or 36 per cent. The output in 1916 excludes all ore containing more than 5 per cent manganese. An analysis of reported quantity mined in 1916, by ranges, in the Lake Superior district shows that the Mesabi range mined 41,325,341 tons, compared with 30,802,409 tons in 1915, an increase of 34 per cent; the Menominee range, 6,649,578 tons, compared with 4,665,465 tons in 1915, an increase of 43 per cent; the Gogebic range, 7,707,101 tons, compared with 4,996,237 tons in 1915, an increase of 54 per cent; the Marquette range, 4,792,987 tons, compared with 3,817,892 tons in 1915, an increase of 26 per cent; the Vermilion range, 1,704,440 tons, compared with 1,541,645 tons in 1915, an increase of 11 per cent; and the Cuyuna range, which in 1916 entered upon its sixth year as a shipper of ore, 1,555,641 tons, compared with 1,120,606 tons in 1915, an increase of 39 per cent. The production of manganiferous iron ore from the Cuyuna range is reported in the chapter on manganese and manganiferous ores elsewhere in Mineral Resources, 1916.

The Mesabi range produced 65 per cent of the entire output of the Lake Superior district and 55 per cent of the entire production of the United States. The Gogebic, Menominee, and Marquette ranges are next in importance, the Gogebic producing 959,200 tons more in 1916 than the State of Alabama, and the Menominee 98,323 tons less than Alabama, which is the next State in importance as a producer after Minnesota and Michigan. The Vermilion range is the fifth in importance of the six producing ranges of the Lake Superior district, but produced only 148,799 tons more than the Cuyuna range, exclusive of manganiferous ore.

*Iron ore mined in the Lake Superior district,[a] 1915 and 1916, in gross tons.*

| Range. | 1915 | 1916 | Increase in 1916. | Percentage of increase in 1916. | Percentage of total output, 1916. | |
|---|---|---|---|---|---|---|
| | | | | | Lake Superior district. | United States. |
| Marquette (Michigan) | 3,817,892 | 4,792,987 | 975,095 | 26 | 8 | 7 |
| Menominee (Michigan and Wisconsin) | 4,665,465 | 6,649,578 | 1,984,113 | 43 | 10 | 9 |
| Gogebic (Michigan and Wisconsin) | 4,996,237 | 7,707,101 | 2,710,864 | 54 | 12 | 10 |
| Vermilion (Minnesota) | 1,541,645 | 1,704,440 | 162,795 | 11 | 3 | 2 |
| Mesabi (Minnesota) | 30,802,409 | 41,325,341 | 10,522,932 | 34 | 65 | 55 |
| Cuyuna (Minnesota) | 1,120,606 | 1,555,641 | 435,035 | 39 | 2 | 2 |
| | 46,944,254 | 63,735,088 | 16,790,834 | 36 | 100 | 85 |

[a] Includes only such Wisconsin mines as are in the true Lake Superior district.

The following table shows the total production of the Lake Superior district, by ranges. The figures prior to 1872 were collected by A. P. Swineford, editor Marquette Mining Journal[1]; those for 1872 to 1877, inclusive, are from the Michigan Mineral Statistics; those for 1878 to 1888, inclusive, were collected by W. J. Stevens[2]; and the later figures were collected by the United States Geological Survey.

*Iron ore produced in the Lake Superior district, 1854–1916, in gross tons.*

| Year. | Marquette. | Menominee. | Gogebic. | Vermilion. | Mesabi. | Cuyuna. | Total. |
|---|---|---|---|---|---|---|---|
| 1854–1869 | 3,112,209 | | | | | | 3,112,209 |
| 1870 | 859,507 | | | | | | 859,507 |
| 1871 | 813,984 | | | | | | 813,984 |
| 1872 | 948,553 | | | | | | 948,553 |
| 1873 | 1,195,234 | | | | | | 1,195,234 |
| 1874 | 899,934 | | | | | | 899,934 |
| 1875 | 881,166 | | | | | | 881,166 |
| 1876 | 993,311 | | | | | | 993,311 |
| 1877 | 1,014,754 | 10,375 | | | | | 1,025,129 |
| 1878 | 1,033,082 | 78,028 | | | | | 1,111,110 |
| 1879 | 1,130,019 | 245,672 | | | | | 1,375,691 |
| 1880 | 1,384,010 | 524,735 | | | | | 1,908,745 |
| 1881 | 1,579,334 | 726,671 | | | | | 2,306,505 |
| 1882 | 1,829,394 | 1,136,018 | | | | | 2,965,412 |
| 1883 | 1,305,364 | 1,047,863 | | | | | 2,353,227 |
| 1884 | 1,559,912 | 895,634 | 1,022 | 62,122 | | | 2,518,690 |
| 1885 | 1,430,362 | 690,435 | 119,500 | 227,075 | | | 2,467,962 |
| 1886 | 1,627,383 | 880,006 | 756,237 | 307,948 | | | 3,571,574 |
| 1887 | 1,851,717 | 1,199,343 | 1,285,265 | 394,010 | | | 4,731,235 |
| 1888 | 1,918,372 | 1,191,097 | 1,433,689 | 511,953 | | | 5,055,411 |
| 1889 | 2,631,026 | 1,876,157 | 2,147,923 | 864,508 | | | 7,519,614 |
| 1890 | 2,863,348 | 2,274,192 | 2,914,081 | 891,910 | | | 8,944,031 |
| 1891 | 2,778,482 | 1,856,124 | 2,041,754 | 945,105 | | | 7,621,465 |
| 1892 | 2,848,552 | 2,402,195 | 3,058,176 | 1,226,220 | 29,245 | | 9,564,388 |
| 1893 | 2,064,827 | 1,563,049 | 1,466,815 | 815,735 | 684,194 | | 6,594,620 |
| 1894 | 1,935,379 | 1,255,255 | 1,523,451 | 1,055,229 | 1,913,234 | | 7,682,548 |
| 1895 | 1,982,080 | 1,794,970 | 2,625,475 | 1,027,103 | 2,839,350 | | 10,268,978 |
| 1896 | 2,418,846 | 1,763,235 | 2,100,398 | 1,200,907 | 3,082,973 | | 10,566,359 |
| 1897 | 2,673,785 | 1,767,220 | 2,163,088 | 1,381,278 | 4,220,151 | | 12,205,522 |
| 1898 | 2,987,030 | 2,275,664 | 2,552,205 | 1,125,538 | 4,837,971 | | 13,779,308 |
| 1899 | 3,634,596 | 3,281,422 | 2,725,648 | 1,643,984 | 6,517,605 | | 17,802,955 |
| 1900 | 3,945,068 | 3,680,738 | 3,104,033 | 1,675,949 | 8,158,450 | | 20,564,238 |
| 1901 | 3,597,189 | 3,697,408 | 3,041,869 | 1,805,996 | 9,303,541 | | 21,445,903 |
| 1902 | 3,734,712 | 4,421,250 | 3,683,792 | 2,057,532 | 13,080,118 | | 26,977,404 |
| 1903 | 3,686,214 | 4,093,320 | 3,422,341 | 1,918,584 | 13,452,812 | | 26,573,271 |
| 1904 | 2,465,448 | 2,871,130 | 2,132,898 | 1,056,430 | 11,672,405 | | 20,198,311 |
| 1905 | 3,772,645 | 4,472,630 | 3,344,551 | 1,578,626 | 20,156,566 | | 33,325,018 |
| 1906 | 4,070,914 | 4,962,357 | 3,484,023 | 1,794,186 | 23,564,991 | | 37,876,371 |
| 1907 | 4,167,810 | 4,779,392 | 3,609,519 | 1,724,217 | 27,245,641 | | 41,526,579 |
| 1908 | 3,309,917 | 2,904,011 | 3,241,931 | 927,206 | 17,725,014 | | 28,108,079 |
| 1909 | 4,291,967 | 4,789,382 | 3,807,157 | 1,097,444 | 27,877,705 | | 41,863,635 |
| 1910 | 4,631,427 | 4,983,729 | 4,746,818 | 1,390,360 | 30,576,409 | | 46,328,743 |
| 1911 | 3,743,145 | 4,062,778 | 3,099,197 | 1,336,938 | 23,126,943 | 181,224 | 35,550,225 |
| 1912 | 3,545,012 | 4,465,456 | 3,926,632 | 1,457,273 | 32,604,756 | 369,739 | 46,368,878 |
| 1913 | 3,977,908 | 4,997,246 | 4,743,515 | 1,536,115 | 36,378,671 | 744,007 | 52,377,362 |
| 1914 | 3,320,763 | 3,671,499 | 4,601,240 | 1,362,416 | 19,808,434 | 776,051 | 33,540,403 |
| 1915 | 3,817,892 | 4,665,465 | 4,996,237 | 1,541,645 | 30,802,409 | 1,120,606 | 46,944,254 |
| 1916 | 4,792,987 | 6,649,578 | 7,707,101 | 1,704,440 | 41,325,341 | 1,555,641 | 63,735,088 |
| | 121,059,070 | 104,902,919 | 95,607,671 | 39,646,882 | 410,984,329 | 4,747,268 | 776,948,139 |

[1] U. S. Geol. Survey Mineral Resources, 1882, p. 116, 1883. [2] Idem, 1891, pp. 39–41, 1893.

## SHIPMENTS AND RECEIPTS.

According to the Iron Trade Review 66,658,466 gross tons of iron ore were shipped in 1916 from the Lake Superior district, including the Iron Ridge and the Baraboo areas in Wisconsin, compared with 47,272,751 tons in 1915. Of the total in 1916, there were 64,734,198 gross tons shipped by boat and 1,924,268 tons by rail, compared with 46,318,804 tons shipped by boat and 953,947 tons by rail in 1915. The shipments from the Lake Superior iron-ore ranges and the Baraboo and Iron Ridge areas as reported to the Survey in 1916 amounted to 66,394,507 gross tons, exclusive of manganiferous iron ore containing 5 per cent or more of manganese.

The following tables give the details of shipments and receipts of Lake Superior iron ore for the last five years:

*Iron ore shipped from the Lake Superior district, 1912–1916 by ports, in gross tons.*[a]

| Shipping port. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Escanaba, Mich | 5,234,655 | 5,399,444 | 3,664,451 | 5,649,289 | 7,457,444 |
| Marquette, Mich | 3,296,761 | 3,137,617 | 1,755,726 | 3,099,589 | 3,858,092 |
| Ashland, Wis | 4,797,101 | 4,338,230 | 3,363,419 | 5,146,772 | 8,057,814 |
| Two Harbors, Minn | 9,370,969 | 10,075,718 | 5,610,262 | 8,642,942 | 10,735,853 |
| Superior, Wis | 14,240,714 | 13,788,343 | 11,309,748 | 8,342,793 | 12,787,046 |
| Duluth, Minn | 10,495,577 | 12,331,126 | 6,318,291 | 15,437,419 | 21,837,949 |
| Total by lake | 47,435,777 | 49,070,478 | 32,021,897 | 46,318,804 | 64,734,198 |
| Total by rail | 785,769 | 876,638 | 707,829 | 953,947 | 1,924,268 |
| Total | 48,221,546 | 49,947,116 | 32,729,726 | 47,272,751 | 66,658,466 |

[a] Iron Trade Review.

*Iron ore shipped from the Lake Superior district, 1912–1916 by months, in gross tons.*[a]

| Month. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| April | 204,042 | 866,387 | 269,686 | 503,332 | 1,658,411 |
| May | 5,919,074 | 7,284,212 | 3,832,063 | 5,012,359 | 8,449,580 |
| June | 7,567,455 | 7,974,444 | 5,502,367 | 6,005,091 | 9,507,576 |
| July | 7,600,233 | 8,204,416 | 5,784,514 | 7,204,020 | 9,750,157 |
| August | 7,760,248 | 7,684,285 | 5,869,477 | 8,081,117 | 9,850,140 |
| September | 7,287,230 | 7,259,062 | 5,431,307 | 7,863,146 | 9,600,786 |
| October | 7,010,219 | 6,526,103 | 4,242,392 | 7,146,373 | 9,116,196 |
| November | 4,072,074 | 3,270,958 | 1,068,681 | 4,445,129 | 5,715,452 |
| December | 14,579 | 18,645 | 1,411 | 57,236 | 1,085,900 |
| Total by lake[b] | 47,435,777 | 49,070,478 | 32,021,897 | 46,318,804 | 64,734,198 |
| Total by rail | 785,769 | 876,638 | 707,829 | 953,947 | 1,924,268 |
| Total | 48,221,546 | 49,947,116 | 32,729,726 | 47,272,751 | 66,658,466 |

[a] Iron Trade Review.

[b] Totals by seasons will be found to vary slightly from the sums of the monthly movements because of corrections.

*Iron ore received at Lake Erie ports, 1912–1916 in gross tons.*[a]

| Port. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Toledo | 1,411,278 | 1,084,215 | 773,711 | 1,158,374 | 2,035,160 |
| Huron | 540,586 | 687,485 | 617,363 | 695,865 | 1,324,112 |
| Lorain | 3,771,350 | 3,709,213 | 1,677,968 | 3,517,258 | 4,613,929 |
| Cleveland | 7,914,836 | 8,812,583 | 5,519,698 | 7,504,697 | 10,669,745 |
| Fairport | 1,810,381 | 2,037,126 | 1,558,134 | 2,001,103 | 2,580,647 |
| Ashtabula | 8,158,080 | 8,336,126 | 5,318,788 | 7,813,101 | 11,474,268 |
| Conneaut | 7,839,831 | 7,849,303 | 6,263,480 | 8,573,509 | 9,588,341 |
| Erie | 547,067 | 713,904 | 260,991 | 707,875 | 1,525,031 |
| Buffalo | 5,060,642 | 5,506,391 | 2,913,273 | 5,339,724 | 7,432,220 |
| Detroit | 418,057 | 363,001 | 332,564 | 459,877 | 425,579 |
| Port Colborne, Ontario, Canada | ..... | ..... | 166,665 | 196,077 | 138,240 |
| | 37,472,108 | 39,099,647 | 25,402,655 | 37,967,460 | 51,807,272 |

[a] Iron Trade Review.

The difference between the shipments of Lake Superior ore and the receipts at Lake Erie ports is accounted for in large part by the quantity of ore delivered at Lake Michigan ports, South Chicago, Ill., Gary and Indiana Harbor, Ind., and Milwaukee, Wis., the receipts at which ports and at smaller places being shown in the table following. It is understood that there is also a loss, probably less than 1 per cent, in handling ore between mines and lower Lake ports.

*Iron ore received at Lake Michigan ports, 1912–1916 in gross tons.*[a]

| Port. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Elk Rapids, Mich | 47,947 | ..... | 28,437 | ..... | ..... |
| East Jordan, Mich | 42,878 | 28,444 | 38,158 | 37,658 | 38,573 |
| Milwaukee, Wis | 138,065 | 234,591 | 93,121 | 187,286 | 239,219 |
| Gary, Ind | 2,088,327 | 2,365,551 | 1,631,564 | 2,421,924 | 2,718,185 |
| Indiana Harbor, Ind | 514,748 | 455,252 | 661,054 | 689,226 | 793,215 |
| South Chicago, Ill | 5,480,105 | 5,572,866 | 3,606,587 | 4,195,976 | 7,740,877 |
| Boyne City, Mich | 45,000 | 45,028 | 50,098 | 40,401 | 43,788 |
| | 8,357,070 | 8,701,732 | 6,109,019 | 7,572,471 | 11,573,857 |

[a] Iron Trade Review.

The following table shows the total quantity of iron ore shipped from the Lake Superior district since 1854, the date of the opening of the Marquette range, the oldest of the Lake Superior ranges. This table gives the shipments as published by the Iron Trade Review and is inserted for comparison with the table giving the total production of the Lake Superior district, without regard to shipments.

*Iron ore shipped from the Lake Superior district, 1854–1916 in gross tons.*[a]

| Year. | Quantity. | Year. | Quantity. | Year. | Quantity. |
|---|---|---|---|---|---|
| 1854 | 3,000 | 1876 | 992,764 | 1898 | 14,024,673 |
| 1855 | 1,449 | 1877 | 1,015,067 | 1899 | 18,251,804 |
| 1856 | 36,343 | 1878 | 1,111,110 | 1900 | 19,050,393 |
| 1857 | 25,646 | 1879 | 1,375,091 | 1901 | 20,589,237 |
| 1858 | 15,876 | 1880 | 1,908,745 | 1902 | 27,571,121 |
| 1859 | 68,832 | 1881 | 2,306,505 | 1903 | 24,289,878 |
| 1860 | 114,401 | 1882 | 2,965,412 | 1904 | 21,822,839 |
| 1861 | 49,909 | 1883 | 2,353,288 | 1905 | 34,384,116 |
| 1862 | 124,169 | 1884 | 2,518,692 | 1906 | 38,565,762 |
| 1863 | 203,055 | 1885 | 2,466,372 | 1907 | 42,266,668 |
| 1864 | 243,127 | 1886 | 3,568,022 | 1908 | 26,014,987 |
| 1865 | 236,208 | 1887 | 4,730,577 | 1909 | 42,586,869 |
| 1866 | 278,796 | 1888 | 5,063,693 | 1910 | 43,442,397 |
| 1867 | 473,567 | 1889 | 7,202,754 | 1911 | 32,793,130 |
| 1868 | 491,449 | 1890 | 9,012,379 | 1912 | 48,221,546 |
| 1869 | 617,444 | 1891 | 7,062,233 | 1913 | 49,947,116 |
| 1870 | 830,940 | 1892 | 9,069,556 | 1914 | 32,729,726 |
| 1871 | 779,607 | 1893 | 6,060,492 | 1915 | 47,272,751 |
| 1872 | 900,901 | 1894 | 7,748,032 | 1916 | 66,658,466 |
| 1873 | 1,162,458 | 1895 | 10,429,037 | | |
| 1874 | 919,557 | 1896 | 9,934,828 | | 770,416,277 |
| 1875 | 891,257 | 1897 | 12,469,038 | | |

[a] Iron Trade Review.

## STOCKS OF IRON ORE AT LAKE ERIE PORTS.

The following tables contain data as to the stocks of iron ore at the Lake Erie ports at the close of navigation and at the opening of navigation for the last five years.

*Stocks of iron ore at lower Lake ports, Dec. 1, 1912–1916, in gross tons.*[a]

| Port. | At close of navigation, Dec. 1— | | | | |
|---|---|---|---|---|---|
| | 1912 | 1913 | 1914 | 1915 | 1916 |
| Toledo, Ohio | 552,016 | 349,047 | 580,600 | 311,799 | 394,889 |
| Sandusky, Ohio | 2,472 | 2,472 | 2,471 | 1,871 | ..... |
| Huron, Ohio | 385,810 | 441,541 | 483,769 | 558,602 | 560,743 |
| Lorain, Ohio | 904,343 | 694,704 | 548,097 | 824,988 | 1,076,105 |
| Cleveland, Ohio | 1,888,560 | 1,930,720 | 1,757,543 | 1,795,962 | 1,936,906 |
| Fairport, Ohio | 565,920 | 478,014 | 406,124 | 413,994 | 474,930 |
| Ashtabula, Ohio | 3,350,553 | 3,202,807 | 2,749,315 | 2,870,204 | 3,266,752 |
| Conneaut, Ohio | 1,429,533 | 1,248,032 | 1,160,639 | 1,216,686 | 1,363,550 |
| Erie, Pa | 661,330 | 594,613 | 484,467 | 589,355 | 625,193 |
| Buffalo, N. Y | 340,261 | 319,726 | 234,880 | 326,800 | 438,712 |
| | 10,080,798 | 9,261,676 | 8,407,905 | 8,910,351 | 10,167,760 |

[a] Iron Trade Review.

*Stocks of iron ore at lower Lake ports, May 1, 1913–1917, in gross tons.*[a]

| Port. | At opening of navigation, May 1— | | | | |
|---|---|---|---|---|---|
| | 1913 | 1914 | 1915 | 1916 | 1917 |
| Toledo, Ohio | 394,984 | 215,534 | 255,343 | 164,637 | 257,030 |
| Sandusky, Ohio | 2,485 | 2,741 | 2,471 | ..... | ..... |
| Huron, Ohio | 293,006 | 308,478 | 462,917 | 286,054 | 333,124 |
| Lorain, Ohio | 399,705 | 245,057 | 377,550 | 173,771 | 503,618 |
| Cleveland, Ohio | 1,428,306 | 1,487,292 | 1,592,783 | 772,721 | 970,973 |
| Fairport, Ohio | 357,995 | 245,038 | 283,591 | 198,636 | 237,645 |
| Ashtabula, Ohio | 2,105,817 | 2,187,622 | 1,963,233 | 1,176,142 | 1,660,818 |
| Conneaut, Ohio | 135,100 | 495,153 | 564,077 | 41,080 | 183,255 |
| Erie, Pa | 449,455 | 461,750 | 412,186 | 342,866 | 406,078 |
| Buffalo, N. Y | 139,624 | 271,492 | 178,152 | 187,498 | 219,691 |
| | 5,706,477 | 5,920,157 | 6,092,303 | 3,343,405 | 4,772,232 |

[a] Marine Review.

## PRICES OF LAKE SUPERIOR IRON ORE.

In the following table are given the selling prices of Lake Superior iron ore per gross ton at the lower Lake ports from 1890 to 1917, according to the Iron Trade Review.

Beginning with the season of 1907 the base for the old range and Mesabi Bessemer ore has been a metallic iron content of 55 per cent natural and that of the old range and Mesabi non-Bessemer ore has been a metallic iron content of 51.5 per cent natural. For the years preceding 1907 the guarantee of Bessemer ores was 55.70 per cent iron, natural, and for the non-Bessemer ores it was 52.80 per cent, except Mesabi non-Bessemer for 1905 and 1906, when the natural iron content was 53 per cent.

For the season 1917 Mesabi Bessemer was listed at $5.70 a gross ton and Mesabi non-Bessemer at $5.05 a ton, compared with $4.20 and $3.55 a ton, respectively, for 1916; old range Bessemer was listed at $5.95 and old range non-Bessemer at $5.20 a ton for 1917, compared with $4.45 and $3.70 a ton, respectively, for 1916. These prices represent increases of $1.50 a ton on all grades of ore, or from 34 per cent to 42 per cent. These increases, though considerable, are not proportionate to the advances in the prices of pig iron during the corresponding period, as indicated on page 544.

The value per unit of iron for 1917 is as follows: Old range Bessemer, 10.82 cents; Mesabi Bessemer, 10.36 cents; old range non-Bessemer, 10.10 cents; Mesabi non-Bessemer, 9.81 cents, compared with 8.09 cents, 7.64 cents, 7.18 cents, and 6.89 cents, respectively, in 1916.

*Selling price of iron ore per gross ton at lower Lake ports at date of buying movement, 1890–1917.*[a]

| Season. | Date of buying movement. | Season iron-ore prices. | | | |
|---|---|---|---|---|---|
| | | Old range Bessemer. | Mesabi Bessemer. | Old range non-Bessemer. | Mesabi non-Bessemer. |
| 1890 | Dec. 15, 1889 | $5.50 | No sale. | $5.25 | No sale. |
| 1891 | June 1, 1891 | 4.50 | No sale. | 4.25 | No sale. |
| 1892 | Jan. 31, 1892 | 4.50 | No sale. | 3.65 | No sale. |
| 1893 | Mar. 15, 1893 | 3.85 | $3.00 | 3.20 | No sale. |
| 1894 | Mar. 1, 1894 | 2.75 | 2.35 | 2.50 | No sale. |
| 1895 | Apr. 1, 1895 | 2.90 | 2.15 | 2.25 | $1.90 |
| 1896 | May 1, 1896 | 4.00 | 3.50 | 2.70 | 2.25 |
| 1897 | May 20, 1897 | 2.60 | 2.25 | 2.15 | 1.90 |
| 1898 | Mar. 20, 1898 | 2.75 | 2.25 | 1.85 | 1.75 |
| 1899 | Feb. 1, 1899 | 3.00 | 2.40 | 2.15 | 2.00 |
| 1900 | Dec. 15, 1899 | 5.50 | 4.50 | 4.25 | 4.00 |
| 1901 | Apr. 15, 1901 | 4.25 | 3.25 | 3.00 | 2.75 |
| 1902 | Feb. 1, 1902 | 4.25 | 3.25 | 3.25 | 2.75 |
| 1903 | Mar. 20, 1903 | 4.50 | 4.00 | 3.60 | 3.20 |
| 1904 | Apr. 15, 1904 | 3.25 | 3.00 | 2.75 | 2.50 |
| 1905 | Feb. 1, 1905 | 3.75 | 3.50 | 3.20 | 3.00 |
| 1906 | Dec. 5, 1905 | 4.25 | 4.00 | 3.70 | 3.50 |
| 1907 | Nov. 5, 1906 | 5.00 | 4.75 | 4.20 | 4.00 |
| 1908 | June 15, 1908 | 4.50 | 4.25 | 3.70 | 3.50 |
| 1909 | May 10, 1909 | 4.50 | 4.25 | 3.70 | 3.50 |
| 1910 | Dec. 24, 1909 | 5.00 | 4.75 | 4.20 | 4.00 |
| 1911 | Apr. 21, 1911 | 4.50 | 4.25 | 3.70 | 3.50 |
| 1912 | Mar. 20, 1912 | 3.75 | 3.50 | 3.00 | 2.85 |
| 1913 | Nov. 19, 1912 | 4.40 | 4.15 | 3.60 | 3.40 |
| 1914 | May 1, 1914 | 3.75 | 3.50 | 3.00 | 2.85 |
| 1915 | Apr. 19, 1915 | 3.75 | 3.45 | 3.00 | 2.80 |
| 1916 | Dec. 7, 1915 | 4.45 | 4.20 | 3.70 | 3.55 |
| 1917 | Nov. 22, 1916 | 5.95 | 5.70 | 5.20 | 5.05 |

[a] Iron Trade Review.

## MINING DEVELOPMENTS.

In a review of developments in 1916 in the mining districts, particularly the Mesabi, Sawhill [1] gave at the beginning of 1917 encouragement for the belief that operators were prepared to supply 1917–18 blast furnace demands. From this review are derived many of the following notes on mines and mining, ore reserves, labor conditions, and the transportation situation.

Among the Mesabi range mines undergoing extensive stripping operations are the Mesabi Mountain, Spruce-Cloquet, Sellers, Adams, Fayal, Mace, Jean, Hill, Annex, Dunwoody, York, Dean, Warren, Smith, Lamberton, and Kevin. On the other ranges work may be mentioned at the Antoine, in the Menominee range; the Plymouth, in the Gogebic range; and the Pennington, in the Cuyuna range.

A number of mines have been converted from open pit to shaft mines, such as the Bray, the Union, and the Genoa, on the Mesabi; others have been changed from underground to open-pit mines, notably the Spruce-Cloquet and the Minnewas, on the same range.

[1] Sawhill, R. V., Confidence pervades ore districts: Iron Trade Rev., Jan. 4, 1917, pp. 85–96.

### IMPROVEMENTS IN HANDLING ORES.

Many mines have been newly equipped with electrical apparatus for driving hoists, pumps, and crushers. The long and slow method of hauling ore by locomotive out of open pits has been replaced at several mines by inclined hoists and conveyors. At the La Rue mine, at Nashwauk, Minn., for instance, the ore is hoisted on conveyor belts in two lifts from the pit to the washer above, a height of 315 feet. The belts are of rubber, 30 inches wide, and are set on a 21° slope. It has been computed that this method of raising the ore from the pit should eliminate 3,600 train trips in one season, or about 12,000 train miles, since it required a trip of nearly 4 miles from the steam shovel to the washer and return. Ore hoisting may thus render unnecessary the long approaches required by open pit mines, provided it is possible otherwise to get steam shovels and ore trains down into the pits.

### ORE CONCENTRATION.

One new washing plant was built in the western Mesabi district in 1916. This plant, which is the sixth to be installed, is at the Webb mine, an underground mine at Hibbing. It is a small washer, designed to concentrate fine ore. Other plants are under construction, among them one at the York mine, near Nashwauk. The experimental washer at the La Rue mine was operated at capacity in 1916 and will be improved and enlarged for 1917. The washer at the Crosby mine, on the Cuyuna range, is reported to have finished its first season of operation with satisfactory results.

Rock separation is a phase of beneficiation of ore that is gaining in importance where the ore bodies are streaked with rock (taconite), and heretofore much of this separation has been partly effected by hand picking. A screening device has been developed at the Susquehanna mine, at Hibbing. Material passing a 2-inch mesh is classed as ore; all that is coarser is rejected in order to eliminate hand picking. The ore at this mine is nearly all rather fine and soft, but the taconite is delivered in lumps, so that the method of screening is admirably adapted to the separation.

### LABOR CONDITIONS.

Labor conditions during 1916 in the Lake Superior iron ranges were rather unsettled and at times even critical. At the height of the shipping season strikes were fomented by agitators not only in the mines but at the docks, and they succeeded in crippling some mining companies temporarily and in checking the output from certain underground mines on the Mesabi and Cuyuna ranges, but they were not successful in curtailing shipments to any great extent, chiefly because it was possible in the open pits to speed up work. At the close of 1916 miners and mine laborers were drawing the highest wages they had ever received. The mining companies, led by the Oliver Iron Mining Co., voluntarily made three increases in wages during the year, the aggregate increases ranging from 27 to 40 per cent, and this proof of the willingness of the operators to share their increased profits with their employees was a strong factor in suppressing the tendency toward strikes. That the strikes may have been encouraged with the intent of shutting off the ore supply from

manufacturers of iron and steel used in war supplies is indicated in the following note:[1]

An interesting sidelight on the disturbed conditions on the Minnesota ranges a few months ago is the suspicion, freely voiced by some but scouted by others, that the trouble was fostered by certain groups interested in the success of the central European powers in the present war. Those who believe the report offer in support the fact that practically all of the men who walked out were natives of these countries, being largely Croatians, with some Austrians. The strike was under Austrian leadership, while the Finns and other nationals held aloof.

It is reported that the results of the enforcement of prohibition in all of the iron-ore areas of Minnesota except the Vermilion range and the Mesabi range east of Buhl, which began December 1, 1915, are believed by the mining operators to have been in general beneficial, although the labor troubles of the summer of 1916 prevented a fair test. Most of the former saloon buildings are now occupied by other kinds of business and savings deposits have increased.

### TRANSPORTATION.

The capability of transportation facilities to handle the large shipments of iron ore from the Lake Superior region was heavily taxed during 1916, particularly that of the Lake fleet. The railroads that carry ore from the ranges to the upper Lake ports as well as the railroads that carry the ore from the lower Lake docks to the furnaces appeared to have adequate facilities. The tonnage of the ore-carrying fleet was limited, however, and not until the close of the season was it realized that the boats could accomplish so much. The notable record achieved was due to several favorable physical factors in addition to the team work developed between the vessel men and the dock and railroad men at the upper and lower Lake ports. The weather throughout the season was generally favorable and the water in connecting channels was higher than normal, thus permitting vessels to carry greater cargoes.

The all-rail movement of ore from mines to furnaces was larger than ever before, aggregating 1,924,268 gross tons, compared with 953,947 tons in 1915. In this total are included more than 600,000 tons shipped to the new plant of the Minnesota Steel Co., at Duluth, which accounts for a large part of the increase.

The completion of iron-ore dock No. 5 of the Duluth, Missabe & Northern Railway, at Duluth in 1915, was noted in this chapter for that year, and in the latter part of 1916 construction of dock No. 6 was begun. This dock, which is expected to be partly completed so as to handle some ore in 1918 will have 384 pockets, the same number as No. 5, but each pocket will have a capacity of 400 tons, compared with 300 tons at dock No. 5. The capacity of No. 6, which will replace No. 2, will thus aggregate more than 150,000 tons of ore, and it is said that it will be the largest loading dock in the world. The steel and the cement for the concrete will be made at the new mills of the United States Steel Corporation at Duluth. Construction work on the new dock, No. 2, of the Duluth & Iron Range Railroad, at Two Harbors, is said to have been advanced during 1916, and plans were under way for a new dock for the Soo Line and for improvements to the terminals of the Chicago & Northwestern Railway, at Ashland, Wis.

[1] Iron Trade Rev., Jan. 4, 1917, p. 91.

### IRON-ORE RESERVES IN MINNESOTA.

Estimates of reserves of ore in Minnesota, prepared by Rukard Hurd, of the Minnesota State Tax Commission, show a net increase of 2,688,303 tons from May 1, 1915, to May 1, 1916. The estimates given in the following table include both ore in the ground and on stock piles, but they do not entirely check with the figures for 1916 published in the Iron Trade Review [1] one year earlier.

*Iron-ore reserves in Minnesota, May 1, 1915 and 1916, in gross tons.*

| Range. | 1915 | 1916 |
|---|---|---|
| Mesabi | 1,389,003,652 | 1,384,636,891 |
| Vermilion | 11,011,974 | 13,057,280 |
| Cuyuna | 72,403,065 | 77,412,823 |
| | 1,472,418,691 | 1,475,106,994 |

## FOREIGN TRADE IN IRON ORE.

### IMPORTS.

The quantity of iron ore imported into the United States in 1916 was 1,325,736 gross tons, valued at $4,566,514, or $3.44 a ton. This represents a decrease in quantity of 15,545 tons, or 1.2 per cent, and an increase in value of $384,869, or 9.2 per cent, as compared with the imports during 1915, which were 1,341,281 gross tons, valued at $4,181,645, or $3.12 a ton. As to the source of the imports in 1916, Cuba produced approximately 54 per cent of the ore, Sweden 16 per cent, Spain 12 per cent, Canada 10 per cent, Chile 5 per cent, and minor quantities came from French Africa and the United Kingdom. Supplies from Germany and Belgium were wholly interrupted in 1915 and 1916 by war, and almost wholly from the United Kingdom, and it is probable that the imports from Newfoundland, which diminished greatly in 1914 and ceased altogether in 1915 and 1916, have been in part diverted to England and in part used at home. Supplies from Canada, however, increased in volume in 1916, largely from the Canadian ranges in the Lake Superior region.

The statistics of imports of iron ore are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

[1] Iron Trade Rev., Jan. 4, 1917, p. 96.

*Iron ore imported into the United States, 1913–1916.*

| Country. | 1913 | | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| Cuba | 1,635,622 | $4,864,186 | 815,017 | $2,288,102 | 831,618 | $2,450,163 | 715,571 | $2,195,409 |
| Spain | 112,580 | 488,798 | 66,982 | 233,287 | 42,092 | 165,827 | 161,422 | 582,691 |
| French Africa | 12,950 | 32,299 | 46,175 | 114,781 | 21,825 | 47,272 | 38,004 | 95,342 |
| Greece | 9,200 | 12,952 | ..... | ..... | 738 | 2,895 | ..... | ..... |
| Newfoundland and Labrador | 213,468 | 325,230 | 38,515 | 57,681 | ..... | ..... | ..... | ..... |
| United Kingdom | 10,431 | 24,726 | 2,663 | 52,814 | ..... | ..... | 140 | 2,019 |
| Germany | 1,323 | 6,223 | 2,256 | 9,222 | ..... | ..... | ..... | ..... |
| Canada | 179,860 | 409,098 | 52,514 | 153,415 | 84,124 | 245,092 | 136,835 | 509,572 |
| Belgium | 6 | 30 | ..... | ..... | ..... | ..... | ..... | ..... |
| Sweden | 356,074 | 1,901,988 | 280,887 | 1,481,747 | 204,632 | 1,061,624 | 212,063 | 1,108,216 |
| Chile | ..... | ..... | 35,180 | 41,760 | 153,600 | 181,271 | 61,701 | 73,265 |
| Other countries | [a] 63,256 | [a] 271,289 | [b] 10,399 | [b] 51,023 | [c] 2,652 | [c] 27,501 | ..... | ..... |
| | 2,594,770 | 8,336,819 | 1,350,588 | 4,483,832 | 1,341,281 | 4,181,645 | 1,325,736 | 4,566,514 |

[a] Of this, 57,225 tons, valued at $216,852, was from Venezuela and 4,400 tons, valued at $46,718, was from Egypt.
[b] Of this, 2,400 tons, valued at $3,600, was from Venezuela, and 6,050 tons, valued at $40,039, was from French Oceania.
[c] Of this, 2,638 tons, valued at $27,280, was from Egypt.

In the following table are shown the annual imports of iron ore into the United States as far as recorded. Iron ore was imported from Europe in large quantities for the first time in 1879, most of the imports prior to that date coming from Canada.

*Iron ore imported into the United States, 1872–1916, in gross tons.*

| Year. | Quantity. | Year. | Quantity. | Year. | Quantity. |
|---|---|---|---|---|---|
| 1872 | 23,733 | 1887 | 1,194,301 | 1903 | 980,440 |
| 1873 | 45,981 | 1888 | 587,470 | 1904 | 487,613 |
| 1874 | 57,987 | 1889 | 853,573 | 1905 | 845,651 |
| 1875 | 56,655 | 1890 | 1,246,830 | 1906 | 1,060,390 |
| 1876 | 17,284 | 1891 | 912,864 | 1907 | 1,229,168 |
| 1877 | 30,669 | 1892 | 806,585 | 1908 | 776,898 |
| 1878 | 28,212 | 1893 | 526,951 | 1909 | 1,604,957 |
| 1879[a] | 150,197 | 1894 | 167,307 | 1910 | 2,591,031 |
| 1879[b] | 284,141 | 1895 | 524,153 | 1911 | 1,811,732 |
| 1880 | 493,408 | 1896 | 682,806 | 1912 | 2,104,576 |
| 1881 | 782,887 | 1897 | 489,970 | 1913 | 2,594,770 |
| 1882 | 589,655 | 1898 | 187,208 | 1914 | 1,350,588 |
| 1883 | 490,875 | 1899 | 674,082 | 1915 | 1,341,281 |
| 1884 | 487,820 | 1900 | 897,831 | 1916 | 1,325,736 |
| 1885 | 390,786 | 1901 | 966,950 | | |
| 1886 | 1,039,433 | 1902 | 1,165,470 | | 37,048,905 |

[a] Fiscal years end. [b] Calendar years begin.

## EXPORTS.

The quantity of iron ore exported from the United States in 1916 amounted to 1,183,952 gross tons, valued at $3,702,496, or $3.13 a ton, as compared with 707,641 gross tons, valued at $2,181,629, or $3.08 a ton, in 1915. This represents an increase in quantity of 476,311 tons, or 67 per cent, and in value of $1,520,867, or 70 per cent. The greater part of the ore was exported to Canada, it is understood for the manufacture of iron and steel at plants in

Ontario. Nearly as much ore was exported to Canada in 1916 as was imported into the United States from all sources.

The data regarding exports are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

*Iron ore exported from the United States, 1916.*

| Country. | Quantity (gross tons). | Value. |
|---|---|---|
| England | 5 | $300 |
| Canada | 1,183,679 | 3,699,727 |
| Brazil | 100 | 605 |
| Chile | 168 | 1,864 |
| | 1,183,952 | 3,702,496 |

*Iron ore exported from the United States, 1899–1916, in gross tons.*

| Year. | Quantity. | Year. | Quantity. |
|---|---|---|---|
| 1899 | 40,665 | 1909 | 455,934 |
| 1900 | 51,460 | 1910 | 748,875 |
| 1901 | 64,703 | 1911 | 768,386 |
| 1902 | 88,445 | 1912 | 1,195,742 |
| 1903 | 80,611 | 1913 | 1,042,151 |
| 1904 | 213,865 | 1914 | 551,618 |
| 1905 | 208,017 | 1915 | 707,641 |
| 1906 | 265,240 | 1916 | 1,183,952 |
| 1907 | 278,608 | | |
| 1908 | 309,099 | | 8,255,012 |

## IRON-ORE INDUSTRY OF CUBA.

The iron ore shipped from Cuba in 1916 amounted to 712,716 gross tons, valued at $2,196,327, compared with 827,448 gross tons, valued at $2,859,900, in 1915, a decrease in quantity of 114,732 tons, or 14 per cent, and in value of $663,573, or 23 per cent. The shipments in 1916 consisted of 64 per cent of hematite, including a little magnetite, and 36 per cent of brown ore. The iron content of the hematite, dried at 212° F., ranged from 57 per cent to 60.03 per cent, and the brown ore carried 35.22 per cent (natural) and 52.44 per cent (nodular). The total stock of ore reported as on hand at the close of 1916 was 628,120 gross tons, compared with 470,544 tons at the close of 1915. This included both natural and nodulized ore.

The following table shows the shipments of iron ore from Cuba since the opening of the mines in 1884. The statistics of the Cuban iron-ore shipments are collected by the United States Geological Survey.

*Iron ore shipped from mines in the Province of Oriente (Santiago), Cuba, 1884–1916, in gross tons.*

| Year. | Juragua Iron Co. (Ltd.) (hematite and magnetite). | Sigua Iron Co. (hematite). | Spanish-American Iron Co. | | Cuban Steel Ore Co. (hematite). | Ponupo Manganese Co., El Cuero Iron mines (hematite). | Total. |
|---|---|---|---|---|---|---|---|
| | | | Daiquiri mines (hematite and a little magnetite). | Mayarí mines (brown ore). | | | |
| 1884 | 25,295 | | | | | | 25,295 |
| 1885 | 80,716 | | | | | | 80,716 |
| 1886 | 112,074 | | | | | | 112,074 |
| 1887 | 94,240 | | | | | | 94,240 |
| 1888 | 206,061 | | | | | | 206,061 |
| 1889 | 260,291 | | | | | | 260,291 |
| 1890 | 363,842 | | | | | | 363,842 |
| 1891 | 264,262 | | | | | | 264,262 |
| 1892 | 335,236 | 6,418 | | | | | 341,654 |
| 1893 | 337,155 | 14,020 | | | | | 351,175 |
| 1894 | 156,826 | | | | | | 156,826 |
| 1895 | 307,503 | | 74,991 | | | | 382,494 |
| 1896 | 298,885 | | 114,110 | | | | 412,995 |
| 1897 | [a] 248,256 | | [b] 206,029 | | | | 454,285 |
| 1898 | 83,696 | | 80,225 | | | | 163,921 |
| 1899 | 161,783 | | 211,442 | | | | 373,225 |
| 1900 | 154,871 | | 293,195 | | | | 448,066 |
| 1901 | 199,764 | | [c] 334,974 | | 17,651 | | 552,389 |
| 1902 | 221,039 | | 455,105 | | 23,590 | | 699,734 |
| 1903 | 155,898 | | 467,629 | | | | 623,527 |
| 1904 | 31,162 | | 356,111 | | | | 387,273 |
| 1905 | 139,828 | | 421,331 | | | | 561,159 |
| 1906 | 133,379 | | 507,195 | | | | 640,574 |
| 1907 | 181,063 | | 469,111 | | | | 650,174 |
| 1908 | 366,580 | | 254,256 | | | | 620,836 |
| 1909 | 356,659 | | 519,752 | | | 59,721 | 936,132 |
| 1910 | 318,814 | | 670,976 | 307,700 | | 165,008 | 1,462,498 |
| 1911 | 355,132 | | 252,717 | 387,791 | | 168,074 | 1,163,714 |
| 1912 | 360,094 | | 463,533 | 446,176 | | 127,994 | 1,397,797 |
| 1913 | 369,213 | | 591,322 | 491,713 | | 130,183 | 1,582,431 |
| 1914 | 267,641 | | 284,507 | 228,949 | | 40,013 | 821,110 |
| 1915 | 215,032 | | 245,590 | 300,896 | | 65,930 | 827,448 |
| 1916 | 212,013 | | 181,602 | 258,451 | | 60,650 | 712,716 |
| | 7,374,303 | 20,438 | 7,455,703 | 2,421,676 | 41,241 | 817,573 | 18,130,934 |

[a] Of this quantity, 5,932 tons were sent to Pictou, Nova Scotia.
[b] Of this quantity, 51,537 tons were sent to foreign ports.
[c] Of this quantity, 12,691 tons were sent to foreign ports.

## BENEFICIATED IRON ORE.

Statistics of beneficiated iron ore were gathered by the Survey for the first time during the canvass for the year 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting, and they showed continued improvement in 1915 and 1916.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 83 mines in 14 States in 1916 and at 66 mines in 14 States in 1915, and in addition at the brown-ore mines of the Spanish-American Iron Co. in Cuba.

In Alabama the ore treated was red hematite and brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total of 996,344 gross tons of beneficiated brown ore, valued at $1,969,706, was marketed from 12 mines in Alabama in 1916, compared with 744,193 tons, valued at $1,278,344, from 9 mines in 1915. Of this, 117,456 tons were hematite run over a picking belt.

One mine in Connecticut, 9 in Georgia, 1 in Iowa, 1 in Massachusetts, and 1 in Missouri reported the concentration of brown ore in 1916. Two mines in Maryland shipped in 1916 the ore which they concentrated in 1915.

Red hematite was beneficiated at 2 mines in Michigan and at 16 mines in Minnesota in 1916. Washing and drying were the principal processes employed, and 3 mines reported crushing and picking also in 1916.

Six mines reported magnetic concentration of magnetite in New Jersey, and at two of them dry tables were employed in addition; two mines reported hand cobbing. At 1 mine in North Carolina, which produces magnetite, the ore was subjected to a rough concentration consisting of electromagnetic cobbing, and 1 mine reported washing of brown ore in 1916.

In New York beneficiation of ore was reported by 11 mines. One of these mines produced red hematite, which was crushed and picked on a belt; one mine crushed washed brown ore; and the rest produced magnetite. The magnetite was mainly concentrated magnetically, although at one mine only crushing and hand picking on slow-moving belt were reported. The total shipments of beneficiated hematite, brown ore, and magnetite in New York amounted to 1,042,823 gross tons, valued at $4,104,398, in 1916, compared with 685,032 tons, valued at $2,055,143, in 1915.

The operations in Iowa are near Waukon, Allamakee County, and employ the Goltra beneficiation process. At the Waukon brown-ore deposit there is much clay, chert, and limestone intimately mixed with the ore as mined. Log washing and hand picking have not proved successful in separating the ore from the impurities economically and the Goltra process has been developed with special reference to treatment of the Waukon ores, although there are probably other deposits in the United States to which it might be equally applicable. In the Goltra process the washing of the ore with water is dispensed with, and instead the ore is subjected to drying, crushing, screening, air separation, picking, roasting, further screening, partial reduction to magnetic iron oxide, and electromagnetic separation. Descriptions and discussion of this process are published elsewhere.[1] The shipments of beneficiated ore amounted in 1916 to 10,151 gross tons. The product was shipped to the furnace of the Mississippi Valley Iron Co., at St. Louis, the owner of the property.

In Pennsylvania 2 mines reported washing brown ore; at one mine the Gröndal concentrating process was employed; and one magnetite mine reported desulphurization by sintering. The shipments of beneficiated ore from this State amounted to 208,351 gross tons, valued

[1] Phillips, W B., Concentration by the Goltra process: Iron Age, Nov. 12, 1914, pp. 1148-1150.
Burchard, E. F., Iron Ore in Cass, Marion, Morris, and Cherokee counties, Tex.: U. S. Geol. Survey Bull. 620, pp. 103-106, 1915.
Howell, J. V., The iron ore deposits near Waukon, Iowa: Iowa Geol. Survey Ann. Rept., 1914, vol. 25, pp. 33-100, 1916.

at $776,830, in 1916, compared with 162,253 tons, valued at $422,264, in 1915.

In Tennessee red hematite from the mines of the Rockwood-Cardiff area was improved by breaking and hand picking, and brown ore from two mines in the west-central belt was beneficiated. At one of these brown-ore mines washing was reported as the only method; the other reported hand picking, washing, and jigging. In all probability, however, hand picking is employed to a greater or less extent at nearly all brown-ore mines where the ore is mixed with gravel. Calcining of brown ore is practiced at one cold-blast furnace. The total beneficiated iron ore shipped from mines in Tennessee in 1916 was 331,499 gross tons, valued at $533,266, compared with 167,844 tons, valued at $207,936, in 1915.

Seven mines reported beneficiation of brown ore in Virginia in 1916. The total shipments of treated ore amounted to 155,436 gross tons, valued at $307,653. Washing, screening, and jigging were the methods employed in treating this ore.

The brown ores of the Mayari mines, Cuba, have been nodulized for many years at an extensive plant on Nipe Bay. The total quantity of this ore reported as shipped in 1916 amounted to 257,605 gross tons, compared with 296,279 tons in 1915.

The total beneficiated ore reported as shipped from mines in the United States in 1916 amounted to 8,105,011 gross tons, valued at $21,037,364, compared with 5,581,029 tons, valued at $11,401,846, in 1915. From such figures as are available, showing the relation between crude ore treated and beneficiated ore recovered, it is apparent that in washing brown ore the ratios, by weight, of crude ore washed to resultant concentrates range from 5:1 to 1.25:1; in concentrating red hematite, the ratios range from 2.05:1 to 1.05:1; and in magnetite they range from 2.664:1 to 1.053:1.

*Beneficiated iron ore shipped from mines in the United States, 1915 and 1916.*

| State. | Variety. | 1915 | | 1916 | |
|---|---|---|---|---|---|
| | | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| Alabama | Red hematite, Brown ore | 744,193 | $1,278,344 | 996,344 | $1,969,706 |
| Georgia | Brown ore | 61,602 | 119,634 | 104,583 | 196,771 |
| Michigan | Red hematite | 140,862 | 205,359 | (a) | (a) |
| Minnesota | do | 3,030,549 | 5,572,845 | 4,576,249 | 10,801,034 |
| New Jersey | Magnetite | 360,325 | 1,049,530 | 528,064 | 1,877,056 |
| New York | Red hematite, Brown ore, Magnetite | 685,032 | 2,055,143 | 1,042,828 | 4,104,398 |
| Pennsylvania | Red hematite, Brown ore, Magnetite | 162,253 | 422,264 | 208,351 | 776,830 |
| Tennessee | Red hematite, Brown ore | 167,844 | 207,936 | 331,499 | 533,266 |
| Virginia | Brown ore, Magnetite | 155,956 | 343,045 | 155,436 | 307,653 |
| Other States b | Red hematite, Brown ore, Magnetite | 72,413 | 147,746 | 161,642 | 470,650 |
| | | 5,581,029 | 11,401,846 | 8,105,011 | 21,037,364 |

a Included in "Other States."

b 1915: Connecticut, Massachusetts, Missouri, and North Carolina; 1916: Connecticut, Iowa, Maryland, Massachusetts, Michigan, Missouri, and North Carolina.

## ESSENTIAL FEATURES OF AN IRON-ORE DEPOSIT.

The war in Europe has greatly stimulated prospecting for minerals and ores in the United States, and as a result of this prospecting many specimens are sent to the United States Geological Survey for identification. The majority of specimens are readily identified at sight; some require a brief visual examination; others require more elaborate physical or chemical tests. The Survey is not permitted to make chemical analyses or assays of minerals or ores for private persons or corporations, but it is compatible with the duties of the Survey to inspect a specimen and to state, if possible, what it is; to give an offhand opinion as to whether or not the material constitutes an ore; and to recommend or discourage further expense in prospecting it or in having analyses or assays made.

Iron minerals are among the most common and are abundantly distributed, and naturally many specimens are received by the Geological Survey. It is therefore believed that a few notes on these minerals and on the requirements of a deposit in order to render it of commercial importance may be of interest to those making inquiries on the subject. As stated on page 511 the classes of iron minerals that constitute a source of iron ore are oxides and carbonates. There are three general varieties of oxides, viz, hematite, brown ore, and magnetite. Brief descriptions of each follow.

### SOURCE OF IRON.

The forms in which iron occurs in the earth in combination with other substances are very numerous. Nearly all hard rocks, as well as the softer soils, sands, clays, and many "mineral" waters contain iron in some combination and in varied proportions. Iron is seldom found "native"—that is, occurring in the earth in the form of metallic iron. When it is found in the metallic state, as, for instance, in meteorites that have fallen from space upon the earth, it is not in quantities large enough to be of commercial value. The combination of iron with one or more other substances is called an iron compound, or iron mineral, and where the iron compounds are such that iron can easily be extracted from them and they occur in such abundance that they can be mined profitably these iron compounds are called iron ores.

Iron in combination with other substances is regarded next to aluminum, a metal contained in clay, as the most abundant metal. Thus, according to recent calculations,[1] metallic iron forms about 4.50 per cent of the rock crust of the earth, compared with 7.85 per cent for aluminum.

### IRON ORE.

There are four important types of ores of iron—red iron ore, or hematite; brown ore, or limonite; magnetic ore, or magnetite; and carbonate ore, or siderite—although there are hundreds of minerals in which iron is a constituent. These types of ore may easily be remembered through their most common colors, which are, respectively, red, brown, black, and grayish.

[1] Clarke, F. W., The data of geochemistry, 3d ed.: U. S. Geol. Survey Bull. 616, p. 34, 1916.

### HEMATITE.

Hematite includes all varieties of the anhydrous sesquioxide ($Fe_2O_3$). This is known locally as red hematite, specular ore, gray ore, fossil ore, oolitic ore, etc. Hematite is composed of two parts of the metal iron united with three parts of oxygen. Iron forms 70 per cent by weight of pure hematite and oxygen 30 per cent, and the mineral is known chemically as the sesquioxide of iron or ferric oxide. Hematite may occur as a rock in beds, in veins, or in masses of irregular shape, and it may occur in a soft, earthy state, or as loose débris in the soil, and yet in all these forms be profitably mined if the controlling conditions are favorable. Hematite is easily recognized in the hand specimen by its colors (red to steel-gray and black) and the red mark or streak it leaves when drawn across a rough surface and by its high specific gravity or superior weight as compared with the weight of pieces of ordinary red rock or red clay of equal size. The old-fashioned "keel" or red chalkstone formerly used by carpenters for marking lumber is a form of hematite. Finely ground hematite is used in the manufacture of red paint and other red coloring materials.

Hematite is by far the most important iron ore. It is found in great abundance in the United States in the vicinity of Lake Superior in Minnesota, Michigan, and Wisconsin; in central New York; in the Appalachian region of Alabama, Georgia, Tennessee, and Virginia; and in eastern Wyoming. It also occurs in lesser quantities in Pennsylvania, Maryland, Kentucky, eastern Wisconsin, Utah, and California.

### BROWN ORE.

Brown ore is composed of hydrous oxides of iron, the most common of which is limonite ($2Fe_2O_3.3H_2O$), together with impurities such as silica and alumina. A general formula for these hydrous oxides may be expressed by $nFe_2O_3.nH_2O$. As these oxides are combined with water in several proportions the percentage of iron likewise varies, but it ranges generally from 52 to 66 per cent in the pure mineral. Thus brown ore does not contain quite as high a percentage of iron as hematite, and therefore it can not yield so much metal. Pure limonite contains 59.9 per cent of iron, 25.7 per cent of oxygen, and 14.4 per cent of water. Brown ore occurs in a large variety of forms, nearly all of which have in common a characteristically yellowish-brown to chocolate-brown color and yield a brown streak and powder. Exceptionally certain hydrated sesquioxides of iron may appear bright red, and some may show black surfaces; but these exceptional forms are generally to be found closely associated with a mass of ordinary brown ore, and familiarity with the deposits soon dispels any perplexity regarding the nature of the ore on the part of persons mining or handling it. The specific gravity of brown ore is also higher than that of ordinary rock. Brown ore commonly occurs in irregular masses and lumps, and as ore gravel and sand, embedded in banks of clay, sand, and stone gravel. The ore in places lies in layers, but more commonly in irregular pockets, separated by barren clay, sand, and stone gravel. In places the ore takes the form of hollow concretions or "pots" which may contain some loose sand or clay

in the interior, and also it appears as honeycombed masses ramifying through the inclosing ore-bearing ground.

Limonite is used chiefly as a source of iron, but the brown and yellow forms, called ocher, are used for paint and for making oilcloth and linoleum. A porous variety of limonite is used in the purification of illuminating gas, and also as a contact material in the production of hydrogen gas for inflation of dirigible balloons and for precipitation of fats from oils. Many iron compounds are used in medicines.

Deposits of brown iron ore are common in many portions of the eastern United States, particularly in valleys underlain by limestone. Some of the best-known deposits are in Connecticut, Vermont, Pennsylvania, Virginia, Tennessee, Alabama, northeastern Texas, and in Iowa and Wisconsin near Mississippi River.

### MAGNETITE.

Magnetite ($Fe_3O_4$) is a black iron mineral which is attracted by the magnet. It contains iron and oxygen in the proportion of 3 parts of iron to 4 parts of oxygen, which by weight gives 72.4 per cent of iron and 27.6 per cent of oxygen. Magnetite thus contains the highest percentage of iron of the ores thus far mentioned, and in fact, of all the iron ores. Magnetite usually occurs in granular form and in crystals in veins in comparatively old crystalline rocks, although it may be found in comparatively young volcanic rock.

Magnetite is found in the United States in considerable quantities in the Adirondack region of New York, the Highlands of New Jersey, southern Pennsylvania, eastern Wyoming, central Texas, southwestern Utah, and southern and northern California, and in small quantities in northern Michigan and in other States. It is used chiefly for the production of iron, but the less common variety known as lodestone, which is naturally magnetic, is sold at high prices for museum exhibits and for laboratory purposes. Magnetite is found in the form of sand along streams and on the shores of lakes or seas where it has been concentrated by the action of water. In this form it has not proved of much commercial value as an ore of iron.

### SIDERITE.

Siderite, or iron carbonate ($FeCO_3$), is composed of 1 part of iron, 1 part of carbon, and 3 parts of oxygen and thus contains by weight where pure, approximately 48.3 per cent of iron, 10.3 per cent of carbon, and 41.4 per cent of oxygen. Iron carbonate ore where fresh is generally grayish in color, and occurs in nodules and in layers principally in sedimentary rocks that contain coal and lignite. The carbonate rapidly changes to brown ore on exposure to moist air. Siderite is known locally as spathic iron ore, kidney ore, clay ironstone, and blackband ore. Certain of these names are derived from the appearance of the ore in its different forms. For instance, a bed of carbonate ore that is found on the top of a coal bed in eastern Kentucky is striped with fine black carbonaceous bands.

Iron carbonate, in addition to being found in Kentucky, is common in southeastern Ohio, and occurs to a small extent in Pennsylvania, Alabama, Mississippi, and Texas.

### IMPURITIES IN IRON ORE.

Consideration should be given to some of the principal impurities that are found in iron ores, first, in order to appreciate why a deposit of ore never yields the full percentage of iron that the predominant iron mineral contains, and, second, in order to show the relation of the ore to the operation of the blast furnace. Deposits of iron ore are generally so closely associated with the rocks which inclose them that they contain either mixed with the deposit or chemically combined within it some of the other rock-forming minerals. Among the most common of these minerals are silica, or sand; lime and magnesia, derived from limestone and dolomite; alumina, a clay mineral; manganese, a metal resembling iron; and small quantities of sulphur and phosphorus. The presence of varying percentages of these and other minerals tends, of course, to reduce the percentage of metallic iron that the deposit will yield when mined, and they must be removed as far as possible in mining and almost completely in the process of making iron. Therefore, it is of the utmost importance that the average chemical composition of a deposit of iron ore be ascertained before an attempt is made to mine it.

The average composition may be termed the "quality" of the deposit. The quality is determined chiefly by two men, the prospector and the chemist. The prospector digs trenches and pits or drills holes in the ore and takes samples of it. The chemist analyzes these samples of ore in his laboratory, and finds the percentages of metallic iron, silica, lime, alumina, manganese, sulphur, phosphorus, water, etc., contained in average samples of the ore. On the quality of the ore depend the quantity of fluxing stone and fuel that must be used in the blast furnace and the kind of iron that can be produced.

### RANGE IN COMPOSITION.

Many chemical analyses of commercial grades of these iron ores indicate a range in composition given in the following table:

*Range in chemical composition of commercial grades of iron ore.*

| | Hematite. | Brown ore. | Magnetite. | Carbonate. |
|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Metallic iron | 25–65 | 35–58 | 48–70 | 25–48 |
| Silica | 2–35 | 3–23 | 0.6–20 | 1–23 |
| Alumina | 0.2–9 | 1.4–12 | 0.7–4.5 | 1–5 |
| Lime | Trace to 27 | 0–0.6 | 0.5–4.5 | 0–7 |
| Manganese | Trace to 5 | 0.16–5 | 0.07–1.5 | 0.1–4.7 |
| Sulphur | Trace to 1.5 | Trace to 0.5 | Trace to 1.2 | 0.01–1.8 |
| Phosphorus | 0.013–1.23 | 0.04–1 | Trace to 1.75 | 0.043–0.7 |
| Titanium | 0–0.9 | ..... | 0–1.5 | 0–0.04 |
| Water | 0.3–6 | 8.8–15 | 0.25–0.5 | 0–6.5 |

Under exceptional conditions ores are mined that contain more or less of the common constituents indicated above, but local conditions may determine whether an ore that falls within the limits shown may be mined. For instance, hematite carrying as little as 25 per cent metallic iron would not be considered of value as an ore unless it contained enough lime to flux the silica and alumina present. Most southern red hematites contain considerable quantities of lime and are therefore workable where a highly siliceous ore carrying no more

metallic iron and little lime would not be available under present conditions of metallurgic practice. At present ores averaging less than 25 per cent of metallic iron are not charged into blast furnaces in any considerable quantities, and ores as lean as this can not be used economically unless they carry more than enough lime to flux them and are used in connection with richer ore. In using limestone as a flux it would probably be more desirable to use a stone carrying 15 to 20 per cent of ferric oxide (10.5 to 14 per cent metallic iron) than one containing only 3 to 5 per cent ferric oxide, on account of the higher iron yield of the former. Nevertheless, the more ferruginous limestone would not commercially be classed as an ore; yet a bed carrying 35.5 per cent ferric oxide (25 per cent metallic iron), although in itself not quite rich enough, might be conceded to be an "ore." There are other exceptions to be noted in this table. Some deposits of nontitaniferous magnetite can be so treated by means of crushing and electromagnetic separation that, although they may contain as little as 25 per cent metallic iron, they will yield a high-grade concentrate. Such ores may be used to advantage, especially where they can be concentrated along with richer grades. Considerable phosphorus is present in the mineral apatite associated with Adirondack magnetite; and this and silica are largely eliminated by electromagnetic concentration. The possibilities of various methods of concentration or beneficiation must therefore be taken into consideration in appraising an ore, and this involves consideration of the physical as well as the chemical character of the ore. The content of water is a widely variable item. Some ores contain much absorbed water, which can be driven off by drying. Hematite is found in all stages of hydration, and thus may contain water up to the point where it should really be classed as a brown ore. Hydrated ores are thus concentrated by heating to drive off the chemically combined water. Carbonate ores are calcined to drive off both carbon dioxide and water. Some iron oxides are subjected to a partial reduction and are thus rendered magnetic, and the separation of nonmetallic impurities is thereby greatly facilitated. One brown-ore deposit that averages in the raw state not more than 30 per cent of metallic iron is thus through a complicated process of beneficiation rendered of commercial value. The question of beneficiation is therefore becoming increasingly important; and there must also be taken into consideration the proximity to transportation, and to blast furnaces, to water-power sites for possible electric reduction, as well as the prevailing conditions of the market. The laws of supply and demand that prevail in 1917 make available lower grades of ore than would be considered desirable in times when low prices for iron and steel are current. The question of quantity available is also of importance, for iron ore is so bulky a product, is relatively so low in value even at the best, and involves so large an expenditure for equipment for mining on a satisfactory scale that any deposit should contain several years' supply to be worthy of development.

To summarize, then, the ore should occur in a deposit containing several hundred thousand tons of merchantable grade, susceptible of economical mining and convenient to transportation and markets, if its development is to be seriously considered.

Some notes on prospecting for iron ores are given in the chapter of Mineral Resources on iron ore, pig iron, and steel in 1911, a few copies of which are available for free distribution by the Director of the United States Geological Survey, Washington, D. C.

### DISTRIBUTION OF IRON-ORE DEPOSITS.

The major features of the distribution of iron-ore deposits in the United States are now fairly well known, as most of the ore-bearing districts that are advantageously situated with respect to transportation facilities, fuel supplies, manufacturing centers, and markets have been studied in more or less detail by the United States Geological Survey or by State organizations, including tax commissions, and a number of publications and maps have been issued on the subject, which are listed in the bibliography (pp. 559–564).

The locations of the principal deposits of iron ore in the United States are indicated on a map having a scale of a little less than 100 miles to 1 inch, issued in Mineral Resources for 1908, Part I. A few copies of this map are still available for free distribution. Twenty-eight States are regular producers of iron ore, and several others contain deposits of value. The States in which commercially important deposits of iron ore occur may conveniently be grouped into six geographic divisions, as shown in the following list, in which the varieties of ore found in each are also indicated:

1. Northeastern States: Massachusetts, Connecticut, New York, New Jersey, and Pennsylvania. Magnetite, hematite, and limonite.
2. Southeastern States: Maryland, Virginia, West Virginia, Tennessee, North Carolina, Georgia, and Alabama. Hematite, limonite, and magnetite.
3. Lake Superior States: Michigan, Wisconsin, and Minnesota. Hematite, limonite, and magnetite.
4. Mississippi Valley States: Ohio, Kentucky, Iowa, Missouri, Arkansas, and northeastern Texas. Limonite, hematite, and siderite.
5. Rocky Mountain States: Idaho, Montana, Wyoming, Colorado, New Mexico, Utah, and Nevada. Hematite, magnetite, and limonite.
6. Pacific States: Washington and California. Magnetite and hematite.

## IRON AND STEEL.

The remarkable records of the production and sales of iron and steel for 1916 in comparison with former years are shown in the following pages, the data being derived from several authoritative sources, such as the American Iron & Steel Institute, Metal Statistics, the Iron Age, the Iron Trade Review, and the Bureau of Foreign and Domestic Commerce, besides the producers who report to the United States Geological Survey.

### PRODUCTION, SHIPMENTS, AND VALUE OF PIG IRON, BY STATES.

The bureau of statistics of the American Iron & Steel Institute reports the production in 1916 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces as well as some that were electrically produced as 39,434,797 gross tons, compared with 29,916,213 tons produced in 1915, an increase of 9,518,584 tons, or 32 per cent.

The following table gives the total production of pig iron in 1915 and 1916, by States, according to their rank each year:

*Pig iron, including some ferroalloys, manufactured in the United States in 1915 and 1916, in gross tons.*[a]

| State. | 1915 | 1916 |
|---|---|---|
| Pennsylvania | 12,790,668 | 16,506,284 |
| Ohio | 6,912,962 | 8,602,895 |
| Illinois | 2,447,220 | 3,922,512 |
| New York | 2,104,780 | 2,352,535 |
| New Jersey | | |
| Alabama | 2,049,453 | 2,762,885 |
| Indiana | 1,986,778 | 2,221,708 |
| Michigan | 372,966 | 811,325 |
| Wisconsin | | |
| Minnesota | | |
| West Virginia | 291,040 | 554,590 |
| Kentucky | | |
| Missouri | | |
| Iowa [b] | 271,921 | 437,633 |
| Colorado | | |
| Washington | | |
| California | | |
| Maryland | 251,548 | 501,452 |
| Virginia | 251,346 | 399,885 |
| Tennessee | 177,729 | 355,374 |
| Connecticut | 7,802 | 5,719 |
| Massachusetts | | |
| | 29,916,213 | 39,434,797 |

[a] Bureau of Statistics of the American Iron & Steel Institute.
[b] Ferrosilicon produced in electric furnace for first time in 1916.

According to reports to the United States Geological Survey by the manufacturers, the shipments of pig iron, exclusive of ferroalloys, in 1916 amounted to 39,126,324 gross tons, valued f. o. b. at the furnaces at $663,478,118, as compared with 30,384,486 tons, valued at $401,409,604, in 1915, an increase in quantity of 8,741,838 tons, or 29 per cent, and in value of $262,068,514, or 65 per cent. The average price per ton in 1916 was $16.96, and in 1915 it was $13.21, an increase in 1916 of $3.75 a ton, or 28 per cent. These values represent the approximate price per ton f. o. b. at the furnaces; this approximate price eliminates freight costs, selling commissions, and other items, which are included in the market prices of certain grades of pig iron as published in the trade journals.

The pig iron shipped includes the metal produced from foreign as well as from domestic ore. The quantity and value of pig iron derived from ore imported from Africa, Canada, Chile, Cuba, Nova Scotia, Spain, and Sweden, although it constitutes a very small percentage of the total production, is considerable, as it is calculated that the shipments derived from foreign ore in 1916 amounted to 764,850 gross tons, valued at $15,996,756, as compared with 945,022 tons, valued at $13,011,950, in 1915. In the manufacture in 1916 of 727,550 gross tons of pig iron, 1,295,518 gross tons of foreign iron ore were reported to have been used, thus indicating an average pig-iron yield of 56.16 per cent, as compared with the quantity of imported ore. Domestic ore, including 4,036,022 tons of cinder, scale, scrap, etc., and amounting to 74,805,359 gross tons, was reported in 1916 as used in the manufacture of 37,974,413 tons of pig iron, thus indicating a yield of 50.76 per cent in pig iron from the domestic materials.

*Pig iron shipped from blast furnaces in the United States in 1915 and 1916.*

| State. | 1915 | | 1916 | | Increase in 1916. | | Percentage of increase in 1916. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity. | Value. |
| Alabama | 2,320,255 | $23,757,124 | 2,672,498 | $38,994,660 | 352,243 | $15,237,536 | 15 | 64 |
| Illinois | 2,455,894 | 34,207,901 | 3,857,391 | 67,764,309 | 1,401,497 | 33,556,408 | 57 | 98 |
| Kentucky | 105,700 | 1,420,275 | 144,444 | 2,595,600 | 38,744 | 1,175,325 | 37 | 83 |
| Michigan | 486,106 | 6,624,559 | 505,646 | 8,851,361 | 19,540 | 2,226,802 | 4 | 34 |
| New York | 2,010,076 | 28,178,466 | 2,289,608 | 40,537,240 | 279,532 | 12,358,774 | 14 | 44 |
| Ohio | 6,995,000 | 90,549,626 | 8,689,030 | 136,855,228 | 1,694,030 | 46,305,602 | 24 | 51 |
| Pennsylvania | 12,779,974 | 174,926,891 | 16,351,131 | 293,437,782 | 3,571,157 | 118,510,891 | 28 | 68 |
| Tennessee | 208,298 | 2,519,337 | 329,342 | 4,981,538 | 121,044 | 2,462,201 | 58 | 98 |
| Virginia | 265,616 | 3,408,784 | 444,491 | 7,140,002 | 178,875 | 3,731,218 | 67 | 109 |
| Wisconsin | 302,913 | 3,997,940 | 423,973 | 7,534,327 | 121,060 | 3,536,387 | 40 | 88 |
| Other States [a] | 2,454,654 | 31,818,701 | 3,418,770 | 54,786,071 | 964,116 | 22,967,370 | 39 | 72 |
| | 30,384,486 | 401,409,604 | 39,126,324 | 663,478,118 | 8,741,838 | 262,068,514 | 29 | 65 |

[a] 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

## AVERAGE PRICES.

The average price per gross ton of all kinds of pig iron, by States, from 1911 to 1916, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the prices at the blast furnaces and do not include the prices of ferroalloys.

The average prices for 1915 and 1916 appear low for such active years in the iron industry. Prices, however, did not revive as rapidly as production, and in the early months of the year orders were taken at low prices for delivery late in the year by many producers who did not clearly foresee the future possibilities. At the close of 1915 market prices of pig iron were 35 to 40 per cent above the average for that year and at the close of 1916 they were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year (see fig. 6), so that the average increase in price was only 28 per cent.

*Average price per gross ton of pig iron in the United States, 1911 to 1916.*

| State. | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| Alabama | $10.75 | $10.75 | $12.08 | $10.52 | $10.24 | $14.59 |
| Illinois | 15.30 | 15.26 | 15.83 | 13.59 | 13.93 | 17.57 |
| Kentucky | 15.01 | 15.74 | 16.09 | 12.24 | 13.44 | 17.97 |
| Michigan | 15.34 | 14.30 | 14.69 | 13.78 | 13.63 | 17.51 |
| New York | 15.56 | 14.22 | 15.35 | 14.26 | 14.02 | 17.70 |
| Ohio | 13.68 | 13.07 | 15.02 | 13.46 | 12.96 | 15.75 |
| Pennsylvania | 14.23 | 14.60 | 15.36 | 13.78 | 13.69 | 17.96 |
| Tennessee | 11.56 | 12.29 | 13.22 | 12.05 | 12.09 | 15.13 |
| Virginia | 12.62 | 13.27 | 13.96 | 12.53 | 12.83 | 16.06 |
| Wisconsin | 15.51 | 14.33 | 15.13 | 13.35 | 13.20 | 17.77 |
| Other States [a] | 14.94 | 14.07 | 15.50 | 13.55 | 12.96 | 16.03 |
| Average for United States | 14.07 | 13.93 | 15.08 | 13.42 | 13.21 | 16.96 |

[a] 1911: California, Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

In the following summary of the annual average price per gross ton of pig iron in the United States for the years 1889 to 1916, the prices prior to 1907 include the cost of transportation of some pig iron from blast furnaces to markets. Prior to 1910 the values of blast-furnace ferroalloys are included. Since 1910 the prices represent, as closely as can be ascertained, the average price paid for pig iron at the blast furnaces. The extreme range in prices, from $9.76 in 1894 to $20.92 in 1902, is of interest. The lowest prices were in the years 1894 to 1898, and the highest were in the years 1902 to 1907. However, the prospects are that the average price will in the next few years reach higher points than in the past.

*Average price per gross ton of pig iron in the United States, 1889–1916.*

| | | | | | |
|---|---|---|---|---|---|
| 1889 | $15.78 | 1899 | $18.00 | 1909 | $16.25 |
| 1890 | 16.43 | 1900 | 18.85 | 1910 | 15.45 |
| 1891 | 15.50 | 1901 | 15.25 | 1911 | 14.07 |
| 1892 | 14.32 | 1902 | 20.92 | 1912 | 13.93 |
| 1893 | 11.90 | 1903 | 19.12 | 1913 | 15.08 |
| 1894 | 9.76 | 1904 | 14.13 | 1914 | 13.42 |
| 1895 | 11.14 | 1905 | 16.63 | 1915 | 13.21 |
| 1896 | 10.47 | 1906 | 19.98 | 1916 | 16.96 |
| 1897 | 9.85 | 1907 | 20.56 | | |
| 1898 | 9.90 | 1908 | 15.96 | | |

## MARKET PRICES OF PIG IRON.

The average monthly prices of the principal grades of pig iron either at the blast furnaces or at the nearest market for 1915 and 1916, according to published market quotations, are of interest in comparison with the general average prices per ton of pig iron in the United States ($13.21 and $16.96) reported to the Survey by blast-furnace operators. The accompanying diagram (fig. 6) graphically shows the price curve of basic pig iron at the blast furnaces in the Mahoning and Shenango valleys, Pa., 1911 to 1916, inclusive. The price reached in December, 1916, $30 per ton, is the highest reached in the 6-year period covered in the diagram, and, in fact, at any time in the last 28 years for which the statistics are shown in the preceding table.

*Average monthly prices per ton of principal grades of pig iron, 1915 and 1916.*[a]

| Month. | 1915 | | | | 1916 | | | |
|---|---|---|---|---|---|---|---|---|
| | Foundry pig iron at Valley furnaces. | Foundry pig iron at Birmingham, Ala., furnaces. | Bessemer pig iron at Valley furnaces. | Basic pig iron at Valley furnaces. | Foundry pig iron at Valley furnaces. | Foundry pig iron at Birmingham, Ala., furnaces. | Bessemer pig iron at Valley furnaces. | Basic pig iron at Valley furnaces. |
| January | $12.75 | $9.50 | $13.75 | $12.50 | $18.50 | $14.92 | $21.00 | $18.00 |
| February | 12.75 | 9.50 | 13.64 | 12.50 | 18.50 | 14.64 | 20.50 | 17.88 |
| March | 12.75 | 9.42 | 13.60 | 12.50 | 18.50 | 15.00 | 20.67 | 18.48 |
| April | 12.75 | 9.25 | 13.60 | 12.50 | 18.50 | 15.00 | 21.00 | 18.48 |
| May | 12.75 | 9.47 | 13.60 | 12.50 | 18.44 | 15.00 | 21.00 | 18.21 |
| June | 12.70 | 9.50 | 13.75 | 12.57 | 18.39 | 14.63 | 21.00 | 18.25 |
| July | 12.72 | 9.61 | 13.98 | 12.87 | 18.25 | 14.00 | 21.00 | 18.00 |
| August | 13.71 | 10.77 | 15.12 | 13.98 | 18.27 | 14.00 | 21.00 | 18.00 |
| September | 14.50 | 11.22 | 15.93 | 14.80 | 18.58 | 14.38 | 21.33 | 18.27 |
| October | 14.58 | 11.71 | 16.00 | 15.00 | 20.56 | 15.35 | 23.81 | 20.17 |
| November | 15.82 | 13.14 | 16.67 | 15.88 | 25.60 | 19.72 | 29.40 | 24.80 |
| December | 17.98 | 14.00 | 19.19 | 17.73 | 29.84 | 23.38 | 34.84 | 29.84 |
| Average | 13.81 | 10.59 | 14.90 | 13.78 | 20.16 | 15.84 | 23.05 | 19.87 |

[a] Metal Statistics, 1917.

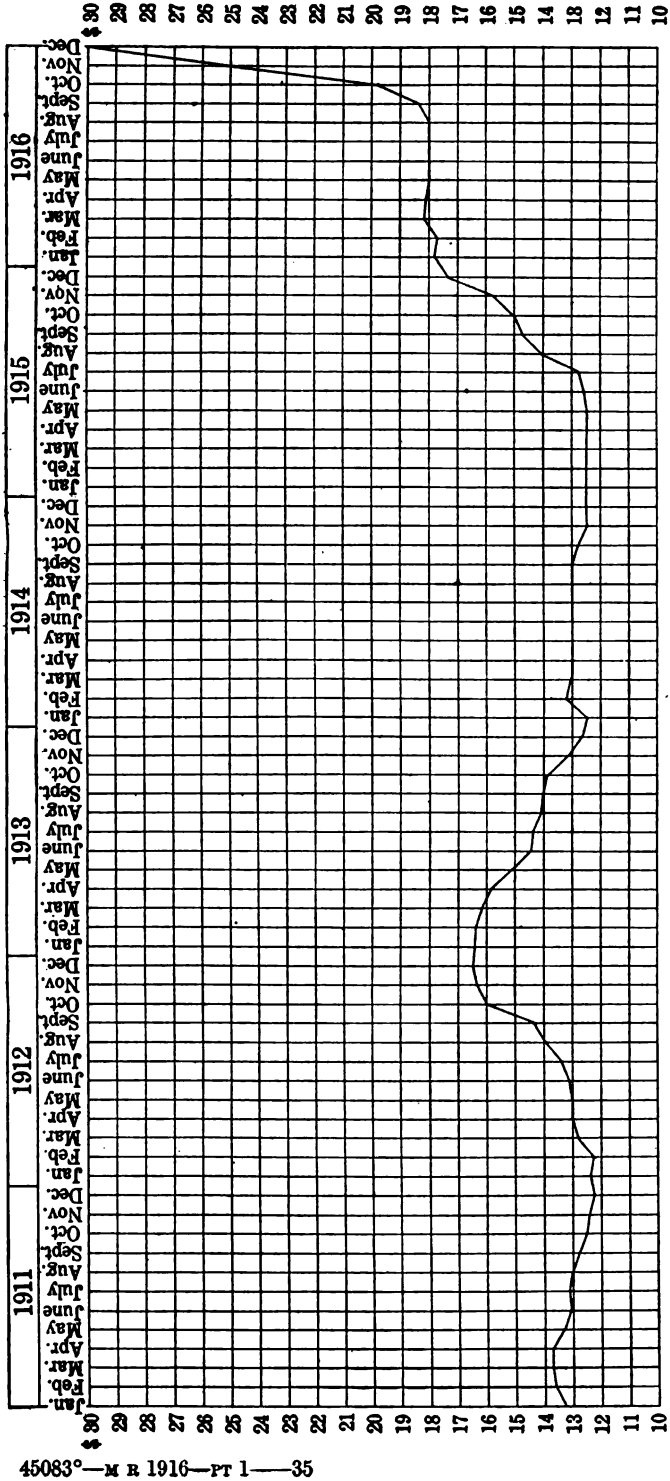


FIGURE 6.—Curve showing prices of basic pig iron at blast furnaces in Mahoning and Shenango valleys, Ohio and western Pennsylvania, 1911 to 1916, by months. Statistics from the Iron Age, Jan. 4, 1917, p. 12.

The following table, compiled by the Iron Trade Review, summarizes the selling prices at Valley furnaces of Bessemer and Foundry No. 2 pig iron at the beginning of the buying season for the last 28 years:

*Selling price of pig iron, 1890–1917, at date of buying movement of iron ore.*

| Season. | Date of buying movement. | Iron prices; Valley. | | Season. | Date of buying movement. | Iron prices; Valley. | |
|---|---|---|---|---|---|---|---|
| | | Bessemer. | Foundry iron No. 2. | | | Bessemer. | Foundry iron No. 2. |
| 1890 | Dec. 15, 1889 | $22.15 | $18.15 | 1904 | Apr. 15, 1904 | $13.35 | $13.15 |
| 1891 | June 1, 1891 | 15.15 | 15.00 | 1905 | Feb. 1, 1905 | 15.50 | 16.00 |
| 1892 | Jan. 31, 1892 | 15.00 | 13.65 | 1906 | Dec. 5, 1905 | 17.25 | 17.25 |
| 1893 | Mar. 15, 1893 | 12.65 | 12.15 | 1907 | Nov. 5, 1906 | 21.50 | 21.50 |
| 1894 | Mar. 1, 1894 | 9.65 | 9.65 | 1908 | June 15, 1908 | 16.00 | 15.00 |
| 1895 | Apr. 1, 1895 | 9.40 | 9.40 | 1909 | May 10, 1909 | 14.75 | 14.25 |
| 1896 | May 1, 1896 | 12.40 | 11.15 | 1910 | Dec. 24, 1909 | 19.00 | 17.25 |
| 1897 | May 20, 1897 | 8.35 | 8.40 | 1911 | Apr. 21, 1911 | 15.00 | 13.75 |
| 1898 | Mar. 20, 1898 | 9.55 | 9.80 | 1912 | Mar. 20, 1912 | 14.25 | 13.25 |
| 1899 | Feb. 1, 1899 | 10.30 | 9.75 | 1913 | Nov. 19, 1912 | 17.25 | 17.50 |
| 1900 | Dec. 15, 1899 | 24.15 | 22.15 | 1914 | May 1, 1914 | 14.00 | 13.25 |
| 1901 | Apr. 15, 1901 | 16.15 | 14.40 | 1915 | Apr. 19, 1915 | 13.60 | 12.75 |
| 1902 | Feb. 1, 1902 | 15.90 | 15.90 | 1916 | Dec. 7, 1915 | 18.50 | 18.00 |
| 1903 | Mar. 20, 1903 | 21.50 | 21.65 | 1917 | Nov. 22, 1916 | 30.00 | 26.00 |

## BLAST FURNACES.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1915 and 1916, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

*Blast furnaces in the United States, 1915 and 1916.*

| State. | Furnaces in blast June 30, 1915. | Dec. 31, 1915. | | | Furnaces in blast June 30, 1916. | Dec. 31, 1916. | | |
|---|---|---|---|---|---|---|---|---|
| | | In. | Out. | Total. | | In. | Out. | Total. |
| Pennsylvania | 96 | 125 | 31 | 156 | 132 | 127 | 30 | 157 |
| Ohio | 50 | 62 | 12 | 74 | 67 | 65 | 12 | 77 |
| Illinois | 12 | 21 | 5 | 26 | 23 | 24 | 0 | 24 |
| Alabama | 20 | 27 | 20 | 47 | 31 | 29 | 18 | 47 |
| New York | 16 | 18 | 9 | 27 | 20 | 18 | 9 | 27 |
| Virginia | 5 | 7 | 15 | 22 | 9 | 9 | 13 | 22 |
| Tennessee | 5 | 6 | 12 | 18 | 12 | 11 | 7 | 18 |
| Colorado | 2 | 2 | 4 | 6 | 4 | 3 | 3 | 6 |
| Iowa | | | | | 0 | 0 | 0 | 0 |
| Missouri | 1 | 1 | 1 | 2 | 1 | 2 | 0 | 2 |
| Oregon | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| Washington | | | | | | | | |
| California | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maryland | 2 | 3 | 2 | 5 | 4 | 4 | 1 | 5 |
| New Jersey | 1 | 1 | 4 | 5 | 1 | 1 | 4 | 5 |
| Wisconsin | 4 | 7 | 1 | 8 | 6 | 5 | 3 | 8 |
| Minnesota | 1 | 2 | 0 | 2 | 3 | 3 | 0 | 3 |
| Indiana | 10 | 10 | 0 | 10 | 10 | 10 | 0 | 10 |
| Michigan | 8 | 11 | 3 | 14 | 12 | 12 | 2 | 14 |
| West Virginia | 1 | 3 | 1 | 4 | 4 | 4 | 0 | 4 |
| Kentucky | 1 | 3 | 3 | 6 | 4 | 4 | 2 | 6 |
| Georgia | 0 | 0 | 4 | 4 | 0 | 0 | 4 | 4 |
| Texas | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 2 |
| Mississippi | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| Connecticut | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| Massachusetts | 0 | 0 | 2 | 2 | 1 | 1 | 1 | 2 |
| | 236 | 310 | 135 | 445 | 344 | 333 | 115 | 448 |

## MONTHLY PRODUCTION OF PIG IRON.

The accompanying diagram (fig. 7) illustrates the course of the manufacture of pig iron by months during the last six years. The moderate production during 1911, broken by alternating declines and recoveries, the rising production of 1912 and early 1913, the decline from the middle of 1913 to the close of 1914 broken by feeble rallies in March and August, 1914, and finally the rapid rise in production from month to month throughout 1915 broken only slightly in November, the high level maintained continuously above 3,000,000 tons throughout 1916, culminating in the record production in October of 3,508,849 gross tons, are graphically indicated.

## PRODUCTION OF PIG IRON, BY GRADES.

The statistics of production of the principal grades of pig iron have been published by the American Iron and Steel Institute for 1912 to 1916, as follows:

*Pig iron manufactured in the United States, 1912–1916, by grades, in gross tons.*

| Grade. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Bessemer and low phosphorus | 11,664,015 | 11,590,113 | 7,859,127 | 10,523,306 | 14,422,457 |
| Basic (mineral fuel) | 11,417,886 | a12,536,693 | a 9,670,687 | a13,093,214 | 17,684,087 |
| Forge pig iron | 469,183 | 324,407 | 361,651 | 316,214 | 348,344 |
| Foundry and ferrosilicon | 5,073,873 | 5,220,343 | 4,533,254 | 4,864,348 | 5,553,644 |
| Malleable | 825,643 | 993,736 | 671,771 | 829,921 | 921,486 |
| Spiegeleisen | 96,346 | 110,338 | 79,935 | 97,885 | 194,002 |
| Ferromanganese | 125,378 | 119,495 | 106,083 | 129,072 | 221,532 |
| White, mottled, direct castings, etc | 54,613 | 71,027 | 49,736 | 62,253 | 89,245 |
| | 29,726,937 | 30,966,152 | 23,332,244 | 29,916,213 | 39,434,797 |

a Includes a small quantity of basic iron made with charcoal.

## PRODUCTION OF PIG IRON ACCORDING TO FUEL USED.

In the following table are given the statistics of the American Iron and Steel Institute showing the production of pig iron, according to the fuel used, from 1912 to 1916. The charcoal figures include small quantities of pig iron made with charcoal and electricity. The totals for each of the five years also include small quantities of ferroalloys made with electricity, coke and electricity, etc.

*Pig iron manufactured in the United States, 1912–1916, by fuel used, in gross tons.*

| Fuel used. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Bituminous, chiefly coke | 29,132,733 | 30,326,130 | 22,976,856 | 29,535,308 | 38,844,598 |
| Anthracite and coke | 236,467 | 277,595 | 89,569 | 84,753 | 217,788 |
| Anthracite alone | 10,712 | 22,446 | 1,895 | ..... | ..... |
| Charcoal | 347,025 | 339,981 | 263,924 | 296,152 | 372,411 |
| | 29,726,937 | 30,966,152 | 23,332,244 | 29,916,213 | 39,434,797 |

## TOTAL PRODUCTION OF PIG IRON.

The table on page 549 shows the production of pig iron, including the commoner ferroalloys, in the United States as far as has been recorded. The statistics for 1912 to 1916 are those of the American Iron and Steel Institute; those for years from 1854 to 1911 were collected by the American Iron and Steel Association; those for 1810, 1840, and 1850 are census figures; those for the other years are largely estimates by early statisticians.

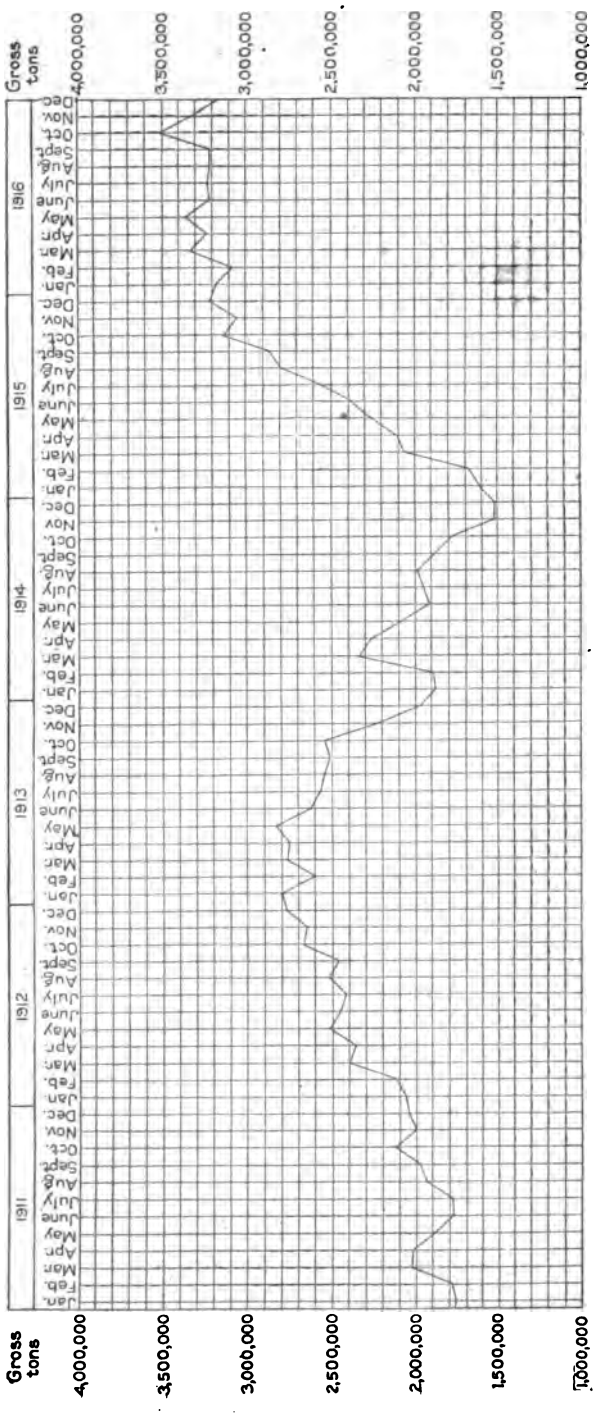


FIGURE 7.—Curve showing production of coke and anthracite pig iron in the United States, 1911 to 1916, by months. Statistics from the Iron Age, Jan. 4, 1917, p. 114.

*Pig iron manufactured in the United States, 1810–1916, in gross tons.*

| Year. | Quantity. | Year. | Quantity. | Year. | Quantity. |
|---|---|---|---|---|---|
| 1810 | 53,908 | 1866 | 1,205,663 | 1893 | 7,124,502 |
| 1820 | 20,000 | 1867 | 1,305,923 | 1894 | 6,657,388 |
| 1828 | 130,000 | 1868 | 1,431,250 | 1895 | 9,446,308 |
| 1829 | 142,000 | 1869 | 1,711,287 | 1896 | 8,623,127 |
| 1830 | 165,000 | 1870 | 1,665,179 | 1897 | 9,652,680 |
| 1831 | 191,000 | 1871 | 1,706,793 | 1898 | 11,773,934 |
| 1832 | 200,000 | 1872 | 2,548,713 | 1899 | 13,620,703 |
| 1840 | 286,903 | 1873 | 2,560,963 | 1900 | 13,789,242 |
| 1842 | 215,000 | 1874 | 2,401,362 | 1901 | 15,878,354 |
| 1846 | 765,000 | 1875 | 2,023,733 | 1902 | 17,821,307 |
| 1847 | 800,000 | 1876 | 1,868,961 | 1903 | 18,009,252 |
| 1848 | 800,000 | 1877 | 2,066,594 | 1904 | 16,497,033 |
| 1849 | 650,000 | 1878 | 2,301,315 | 1905 | 22,992,380 |
| 1850 | 563,755 | 1879 | 2,741,853 | 1906 | 25,307,191 |
| 1852 | 500,000 | 1880 | 3,835,191 | 1907 | 25,781,361 |
| 1854 | 657,337 | 1881 | 4,144,254 | 1908 | 15,936,018 |
| 1855 | 700,159 | 1882 | 4,623,323 | 1909 | 25,795,471 |
| 1856 | 738,515 | 1883 | 4,595,510 | 1910 | 27,303,567 |
| 1857 | 712,640 | 1884 | 4,097,868 | 1911 | 23,649,547 |
| 1858 | 629,548 | 1885 | 4,044,526 | 1912 | 29,726,937 |
| 1859 | 750,560 | 1886 | 5,683,329 | 1913 | 30,966,152 |
| 1860 | 821,223 | 1887 | 6,417,148 | 1914 | 23,332,244 |
| 1861 | 653,164 | 1888 | 6,489,738 | 1915 | 29,916,213 |
| 1862 | 703,270 | 1889 | 7,603,642 | 1916 | 39,434,797 |
| 1863 | 846,075 | 1890 | 9,202,703 | | |
| 1864 | 1,014,282 | 1891 | 8,279,870 | | 589,339,408 |
| 1865 | 931,770 | 1892 | 9,157,000 | | |

## FOREIGN TRADE IN PIG IRON.

### IMPORTS.

The quantity of pig iron and ferroalloys, the principal of which were ferromanganese and ferrosilicon, imported into the United States in 1916 was 135,349 gross tons, compared with 89,836 tons imported in 1915, an increase of 45,513 tons, or 51 per cent. The United Kingdom furnished the largest quantity in both years; Canada, China, and British India followed in order of importance in 1916.

The statistics of imports of iron are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce, and the following table gives the imports from the various countries from 1912 to 1916:

*Pig iron, including kentledge, ferromanganese, ferrosilicon, and spiegeleisen, imported into the United States, 1912–1916, in gross tons.*

| Country. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| North America: | | | | | |
| Canada | 4,998 | 4,609 | 25,968 | 21,166 | 33,716 |
| Newfoundland and Labrador | ..... | ..... | 200 | ..... | ..... |
| West Indies | ..... | 72 | ..... | ..... | ..... |
| South America | ..... | ..... | 250 | ..... | ..... |
| Europe: | | | | | |
| Austria-Hungary | 400 | 340 | 899 | ..... | ..... |
| Belgium | ..... | 256 | 500 | ..... | ..... |
| France | ..... | 179 | 40 | 20 | ..... |
| Germany | 5,924 | 8,358 | 10,609 | 600 | 341 |
| Italy | ..... | ..... | 550 | ..... | ..... |
| Netherlands | 492 | 460 | 2,539 | ..... | ..... |
| Norway | ..... | 117 | 225 | ..... | ..... |
| Sweden | ..... | 2,002 | 2,329 | 1,392 | 792 |
| Switzerland | ..... | 1,680 | ..... | ..... | ..... |
| United Kingdom: England | 110,526 | 131,340 | 90,627 | 59,105 | 89,764 |
| United Kingdom: Scotland | | 1,581 | 1,012 | 792 | ..... |
| Asia: | | | | | |
| British India | ..... | 2,439 | 1,310 | 2,382 | 1,313 |
| China | 1,750 | 3,017 | 200 | 3,430 | 8,861 |
| China, leased territory (British) | ..... | ..... | 1,285 | ..... | ..... |
| Hongkong | ..... | ..... | 200 | ..... | ..... |
| Japan | ..... | ..... | 70 | 250 | 562 |
| Oceania | ..... | ..... | 90 | ..... | ..... |
| Other countries | 5,235 | ..... | ..... | 699 | ..... |
| | 129,325 | 156,450 | 138,903 | 89,836 | 135,349 |

## EXPORTS.

The quantity of pig iron exported from the United States in 1916 was 607,236 gross tons, compared with 224,509 tons in 1915, an increase of 382,727 tons, or 170 per cent. The increase in value, from $3,667,167 in 1915 to $15,381,431, represented more than 319 per cent. The largest quantity was shipped in 1916 to Italy, and important quantities were shipped also to Canada, England, France, Netherlands, Sweden, Denmark, and Norway. The exports of pig iron to South American countries are very small. Several European countries have been added to the list in 1916, and the exports to Switzerland, Denmark, Netherlands, Spain, Norway, and Sweden at this time are of significance.

The following table shows the exports of pig iron from the United States to the various foreign countries by calendar years from 1912 to 1916, according to records of the Bureau of Foreign and Domestic Commerce:

*Pig iron exported from the United States to foreign countries, 1912–1916, in gross tons.*

| Country. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| North America: | | | | | |
| Canada | 208,581 | 193,396 | 57,852 | 60,197 | 101,277 |
| Costa Rica | ..... | 310 | 18 | 50 | 68 |
| Mexico | 804 | 85 | 454 | 684 | 676 |
| Panama | 1,606 | 3,921 | 1,056 | 2,316 | 1,968 |
| West Indies: | | | | | |
| Cuba | 734 | 646 | 593 | 844 | 5,338 |
| South America: | | | | | |
| Argentina | ..... | 792 | 1,042 | 912 | 380 |
| Brazil | 50 | 1,305 | 575 | 804 | 1,176 |
| Chile | 1,964 | 690 | 1,875 | 2,716 | 6,500 |
| Peru | 835 | 172 | 200 | 286 | 682 |
| Europe: | | | | | |
| Austria-Hungary | 14,806 | 4,601 | 1,150 | ..... | ..... |
| Belgium | 1,698 | 4,715 | 1,219 | ..... | ..... |
| Denmark | 168 | 48 | ..... | ..... | 17,380 |
| France | 827 | 752 | 397 | 9,414 | 71,226 |
| Germany | 2,403 | 1,723 | 749 | ..... | ..... |
| Greece | ..... | ..... | ..... | ..... | 50 |
| Italy | 11,954 | 24,551 | 14,288 | 81,792 | 234,213 |
| Netherlands | ..... | 1,516 | 1,467 | 1,993 | 22,464 |
| Norway | ..... | ..... | ..... | ..... | 11,267 |
| Russia in Europe | ..... | ..... | ..... | ..... | 926 |
| Spain | ..... | ..... | ..... | ..... | 8,464 |
| Sweden | ..... | ..... | ..... | ..... | 20,707 |
| Switzerland | ..... | ..... | ..... | ..... | 3,671 |
| United Kingdom— | | | | | |
| England | 25,617 | 20,972 | 18,013 | 57,368 | 88,315 |
| Scotland | | 396 | 148 | ..... | 2,249 |
| Ireland | | 26 | ..... | ..... | 357 |
| Asia: | | | | | |
| Japan | ..... | 2,293 | 2,938 | 1,811 | 5,033 |
| Oceania: | | | | | |
| Australia | ..... | 14,354 | 10,099 | 2,008 | 433 |
| New Zealand | ..... | 85 | ..... | ..... | 260 |
| All other countries | 629 | 299 | 290 | 1,814 | 2,156 |
| | 272,676 | 277,648 | 114,423 | 224,509 | 607,236 |
| Value | $3,832,765 | $4,026,306 | $1,638,102 | $3,667,167 | $15,381,431 |

## PRODUCTION OF PIG IRON IN PRINCIPAL COUNTRIES.

The following table is taken from "Metal Statistics." The grand totals are regarded as representing the world's production of pig iron, and the fact that the United States has in recent years produced between 40 and 48 per cent of the total and yet exports relatively so little is of interest.

*Pig iron manufactured in principal countries in 1850, 1890, 1900, 1910, 1913, 1914, and 1915, in gross tons.*[a]

| Country. | 1850 | 1890 | 1900 | 1910 | 1913 | 1914[b] | 1915[b] |
|---|---|---|---|---|---|---|---|
| United States | 563,755 | 9,202,703 | 13,789,242 | 27,303,567 | 30,966,152 | 23,332,244 | 29,916,213 |
| Germany | 350,000 | 4,584,882 | 8,381,373 | 14,559,509 | 19,004,022 | 14,162,147 | 11,603,874 |
| Great Britain | 2,300,000 | 7,904,214 | 8,959,491 | 10,217,022 | 10,481,917 | 9,005,898 | 8,793,659 |
| France | 405,653 | 1,931,188 | 2,669,966 | 3,974,478 | 5,227,378 | 3,500,000 | 4,000,000 |
| Russia | 227,555 | 912,561 | 2,889,789 | 2,992,058 | 4,474,757 | 4,190,000 | 3,638,000 |
| Austria-Hungary | 250,000 | 910,685 | 1,472,495 | 2,153,788 | 2,335,170 | 1,500,000 | 1,929,000 |
| Belgium | 144,452 | 775,385 | 1,001,372 | 1,822,821 | 2,318,767 | 1,500,000 | ..... |
| Canada | ..... | 19,439 | 86,090 | 740,210 | 1,015,118 | 705,972 | 825,420 |
| Sweden | 150,000 | 483,155 | 518,263 | 594,385 | 730,659 | 629,608 | 755,000 |
| Spain | ..... | 176,598 | 289,315 | 367,423 | 418,061 | 400,000 | 421,000 |
| Italy | ..... | 14,094 | 23,569 | 347,657 | 420,011 | 379,028 | 389,000 |
| Other countries | 10,000 | 80,000 | 100,000 | 400,000 | 500,000 | 500,000 | 500,000 |
| | 4,401,415 | 26,994,904 | 40,181,865 | 65,472,918 | 77,892,012 | 59,804,897 | 62,771,166 |

[a] Metal Statistics, 1917, p. 41.
[b] Partly estimated.
NOTE.—The estimate for 1916 is 73,000,000 gross tons.

## FERROALLOYS.[1]

### SHIPMENTS AND VALUE.

The quantity of ferroalloys reported as shipped or used amounted to only about 1.51 per cent of the total marketed production of pig iron during 1916, but the value per ton is so much greater as to have an important influence on the apparent average value of the pig iron, if included with it, and would make it $17.97 a ton, instead of $16.96.

There is generally a sufficient number of producers of the commoner ferroalloys, such as ferromanganese, spiegeleisen, and ferrosilicon, to enable the Survey to publish the production of these three types of alloys separately; but the production of the rarer alloys, such as ferrochrome, ferromolybdenum, ferrotungsten, and ferrovanadium, must be grouped together, and as there are less than three reporting producers of ferrophosphorus the value of this alloy is grouped with that of ferrosilicon, although permission to show quantity has been given for 1916. The values of the rarer alloys were estimated in part for 1914 but not for 1915 and 1916.

The shipments of ferroalloys in 1916, as reported to the United States Geological Survey, were 589,738 gross tons, valued at $50,281,692, as compared with 388,644 gross tons, valued at $17,450,385, in 1915, an increase in quantity of 201,094 tons, or 51.7 per cent, and in value of $32,831,307, or 188.1 per cent, in 1916. Of the shipments in 1916, it is calculated that 223,878 gross tons, valued at $32,207,902, were made from imported ores derived from Brazil, Costa Rica, Panama, Porto Rico, Peru, Cuba, India, and Russia. The ferrovanadium, ferromolybdenum, ferromanganese, spiegeleisen, and ferrotungsten were made in part or wholly from imported ore. The quantity reported falls short of the actual production of the United States, as the output of certain electrically produced ferroalloys is not available for publication by the Geological Survey.

[1] Notes on ores used in manganese ferroalloys are given also in the chapter on the production of manganese and manganiferous ores in Mineral Resources for 1916, and notes on ores for certain other ferroalloys in the chapters on rare metals.

The sales of ferromanganese and spiegeleisen of domestic manufacture in 1916 amounted to 406,940 gross tons, valued at $36,281,695, compared with 258,816 gross tons, valued at $11,656,993, sold in 1915. The figures for ferromanganese and spiegeleisen, which may be shown separately for the last two years, are as follows: For 1916, ferromanganese, 224,103 gross tons, valued at $30,123,493, or an average of $134.42 a ton; spiegeleisen, 182,837 gross tons, valued at $6,158,202, or $33.68 a ton; for 1915, ferromanganese, 144,260 gross tons, valued at $9,253,443, or $64.14 a ton; spiegeleisen, 114,556 gross tons, valued at $2,403,550, or $20.98 a ton. The increases in value are noteworthy. The sales of ferrosilicon and ferrophosphorus in 1916 amounted to 179,274 gross tons, valued at $5,273,088, an average value of $29.41 a ton, compared with 128,263 tons, valued at $2,595,265, or $20.23 a ton, in 1915. The sales of alloys of iron with the rarer metals—chromium, molybdenum, tungsten, and vanadium—as reported to the Survey, amounted in 1916 to 3,524 gross tons, valued at $8,726,909, compared with 1,565 gross tons, valued at $3,198,127, in 1915, an increase in quantity of 1,959 tons and in value of $5,528,782. These alloys were therefore valued at an average price of more than $2,476 a ton in 1916, compared with $2,044 a ton in 1915.

The following table gives an incomplete outline of the sales of ferroalloys in the United States in 1914, 1915, and 1916:

*Ferroalloys of domestic manufacture sold in 1914, 1915, and 1916.*

| Variety of alloy. | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| Ferromanganese | 100,731 | $4,440,253 | 144,260 | $9,253,443 | 224,103 | $30,123,493 |
| Spiegeleisen | 76,625 | 1,586,139 | 114,556 | 2,403,550 | 182,837 | 6,158,202 |
| Ferrosilicon, Ferrophosphorus, Ferrochrome[a], Ferromolybdenum | 77,182 | 1,621,830 | 128,263 | 2,595,265 | 166,308 / 12,966 | 5,273,088 |
| Ferrovanadium, Ferrotungsten (50 per cent or more tungsten) | 986 | 1,702,023 | 1,565 | 3,198,127 | 3,524 | 8,726,909 |
| | 255,524 | 9,350,245 | 388,644 | 17,450,385 | 589,738 | 50,281,692 |

[a] No ferrochrome reported for 1914 or 1915.

Interest in the ferroalloy situation developed greatly during 1916 as a consequence of the European war, and for more details readers are referred to special articles in the trade papers.[1] In addition to the greatly increased demand for certain of these alloys, brought about by the necessity for much larger quantities of steel than ever before, several other factors have tended to complicate the situation. Formerly the United States imported the greater part of its supply of certain ores, such as manganese and chromite; there was also imported the greater part of the domestic consumption of certain alloys, such as ferromanganese. Restrictions by foreign governments on the quantity of alloys that could be sent to the United States, together with the enormously increased prices that could be obtained,

[1] Brown, De Courcy, Metals and alloys in the steel industry: Iron Age, Jan. 4, 1917, pp. 21-23. American skill solves problem: Iron Trade Rev., Jan. 4, 1917, pp. 24-25.

have resulted in a large increase in domestic production and in facilities for production. Decreasing facilities for ocean shipping have also contributed to this result, but they have more seriously threatened or affected the importation of ores such as manganese from India, Russia, Brazil, and Cuba, chromite from New Caledonia, Rhodesia, Canada, Greece, and Turkey, vanadium from Peru, and tungsten from other South American countries, so that, notwithstanding the fact that American manufacturers have been able to solve to a large extent the technical problems of production in this country of these indispensible alloys, they faced toward the close of 1916 a serious shortage of the essential raw materials. Under these conditions prices rose greatly on all the important alloys and on the ores. At times the prices on certain alloys reached extraordinary levels. Exploration for deposits of ore was stimulated, new deposits were opened, idle deposits were reopened, and the result was that production of domestic ores was increased considerably, but not to an extent at all sufficient to render the United States independent of foreign supplies.

In 1916 ferromanganese was reported to have been made at 14 localities in the United States, 8 of which were in Pennsylvania, 2 in Alabama, 2 in Illinois, 1 in Maryland, and 1 in California; spiegeleisen was made at 12 places, 7 of which were in Pennsylvania, 2 in Alabama, 1 in Maryland, 1 in Illinois, and 1 in Colorado; ferrosilicon at 10 places, 4 of which were in Ohio, 1 in Maryland, 1 in New York, 1 in Pennsylvania, 1 in Kentucky, 1 in Illinois, and 1 in Iowa; ferrotungsten at 3 places, all of them in Pennsylvania; ferrovanadium at 3 places, all in Pennsylvania; ferrophosphorus at 2 places, both in Tennessee; ferromolybdenum at 1 place in Pennsylvania; and ferrochrome at 1 place in California. The above-mentioned known operations do not include all those at which ferroalloys are manufactured electrically.

The following records of average contract prices of 80 per cent ferromanganese at eastern seaboard and of 20 per cent spiegeleisen by months for the last two years are of interest:

*Prices per ton of ferromanganese and spiegeleisen, 1915 and 1916.*[a]

| Month. | Ferromanganese. | | Spiegeleisen. | |
|---|---|---|---|---|
| | 1915 | 1916 | 1915 | 1916 |
| January | $68.00 | $110.00 | $25.00 | $32.50 |
| February | 100.00 | 140.00 | 25.50 | 42.50 |
| March | 100.00 | 175.00 | 26.00 | 55.00 |
| April | 100.00 | 175.00 | 26.00 | 60.00 |
| May | 100.00 | 175.00 | 26.00 | 60.00 |
| June | 105.00 | 175.00 | 26.00 | 55.00 |
| July | 103.00 | 175.00 | 26.00 | 47.50 |
| August | 105.00 | 170.00 | 26.00 | 47.50 |
| September | 110.00 | 164.00 | 29.00 | 45.00 |
| October | 105.00 | 160.00 | 30.00 | 40.00 |
| November | 100.00 | 155.00 | 30.00 | 45.00 |
| December | 100.00 | 162.50 | 30.00 | 50.00 |

[a] Iron Trade Review, Jan. 4, 1917, p. 25.

Early in the year spot prices were much higher. Ferromanganese, which started at $150 a ton, reached the unprecedented figures of $400 to $450 at seaboard in March and April, and spot spiegeleisen commanded $100 in April. From this period the increasing domestic production of merchant ferromanganese and spiegeleisen began to relieve the stringency, and in July prices for immediate and future delivery coincided.

With regard to market prices of other ferroalloys data are far from complete. Toward the close of the year ferrochrome was sold at 14 to 15 cents per pound of contained chromium. At the latter figure alloy containing 60 per cent chromium would be valued at nearly $200 a gross ton. Notes on prices of ferrosilicon, ferrocobalt, ferrotungsten, and ferrovanadium, as published by the Iron Age,[1] are as follows:

The year 1916 opened with 50 per cent electric-furnace ferrosilicon in only fair demand. Consumers had all contracted for their supplies and producers seemed to have very little difficulty in keeping up deliveries. Regular quotations in January called for $83 to $85 per gross ton, Pittsburgh, and there was no apparent change from these figures until October, when it was announced that on account of greatly increased cost of apparatus entering into the production of silicon, the price would be $95 to $100 for 1917. However, some 1917 material was taken below these figures. * * * This product is also influenced by the price of scrap.

The year 1916 opened with tungsten very steady at about $6 to $6.50 per pound, but the market gained strength in February and rose to $8.50 to $9.50 per pound, which prices held until June. The demand at this point considerably exceeded the supply. Toward the end of June large quantities of tungsten concentrates appeared on the market, and the price of the metal and alloy began to drop violently. * * * In July the market found itself at $2.75 per pound, but eased off gradually during August, September, and October to about $2.60 per pound. In the last two months of the year there being no visible stocks of ore on the market, the metal advanced and there seems to be a fair and steady demand up to about $2.75 per pound for the powdered metal; although some ferrotungsten is offered below this figure.

Vanadium is used principally in high-speed and other cutting tool steels, automobile steels, and steel castings which must withstand heavy dynamic stresses, and the production of these items has been enormously increased since the war began. The price has not advanced in proportion to those of other alloys and throughout the year has been between $2.25 and $3 per pound of contained vanadium. * * * The market value of vanadium is influenced more particularly by the fluctuations of metallic aluminum than by any other element, since practically all high-grade ferrovanadium is manufactured by the Thermit process in which aluminum is the principal reagent.

## IMPORTS.

According to the reports of the Bureau of Foreign and Domestic Commerce, the imports of ferromanganese into the United States in 1916 for consumption were 90,928 gross tons, valued at $9,240,528, or $101.62 a ton, as compared with 55,263 gross tons, valued at $3,333,699, or $60.32 a ton, in 1915. There were no imports of spiegeleisen in 1916, as compared with 200 gross tons, valued at $5,110, or $25.55 a ton, in 1915. The imports of the alloys of the rarer metals are not all reported separately. For instance, the imports of ferrochrome are combined with those of chromium, those of ferromolybdenum are combined with those of the metal molybdenum, and those of ferrotungsten are included with those of tungsten. For the sake of comparison, however, such statistics as are available are presented in the following two tables:

[1] Iron Age, Jan. 4, 1917, p. 21.

*Ferroalloys imported for consumption in the United States in 1914, 1915, and 1916.*

| Variety of alloy. | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value | Quantity (gross tons). | Value. |
| Chrome or chromium and ferrochrome | 200 | $21,553 | 32 | $1,662 | 10 | $1,998 |
| Ferrophosphorus | 26 | 1,136 | 12 | 617 | ..... | ..... |
| Ferrosilicon | 6,249 | 341,925 | 5,128 | 311,219 | 6,740 | 384,384 |
| Molybdenum and ferromolybdenum | .10 | 59 | ..... | 203 | ..... | ..... |
| Titanium and ferrotitanium | 18 | 8,356 | ..... | ..... | 100 | 8,126 |
| Tungsten and ferrotungsten | 195 | 222,447 | 7 | 9,588 | 38 | 157,711 |
| Ferromanganese | 82,997 | 3,619,607 | 55,263 | 3,333,699 | 90,928 | 9,240,528 |
| Spiegeleisen | 2,870 | 71,147 | 200 | 5,110 | ..... | ..... |
| | 92,555.10 | 4,286,230 | 60,642 | 3,662,098 | 97,816 | 9,792,747 |

*Ferromanganese and ferrosilicon imported into the United States in 1915 and 1916.*

| Country. | Alloy. | 1915 | | 1916 | |
|---|---|---|---|---|---|
| | | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| British India | Ferromanganese | ..... | ..... | [a] 1,313 | $190,649 |
| Canada | Ferrosilicon | 4,887 | $274,059 | 6,691 | 379,133 |
| England | Ferromanganese | ..... | ..... | [a] 41,832 | 4,626,509 |
| | Ferrosilicon | 319 | 33,165 | 49 | 5,251 |
| France | Ferrosilicon | 20 | 2,906 | ..... | ..... |

[a] Included in "All other pig iron" prior to July, 1916.

## PRODUCTION OF STEEL, BY STATES AND KINDS.

The following tables showing the production of steel were compiled by the bureau of statistics of the American Iron and Steel Institute. No data whatever are available on the value of the steel output.

*Bessemer steel ingots and castings manufactured in the United States, 1912–1916, in gross tons.*

| State. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Ohio | 4,285,673 | 4,024,662 | 2,862,700 | 3,929,665 | 4,711,784 |
| Pennsylvania | 3,157,928 | 2,954,818 | 2,014,526 | 2,507,243 | 3,444,163 |
| Illinois | 1,559,576 | 1,475,274 | 871,110 | 1,270,502 | 1,958,259 |
| Other States | 1,324,724 | 1,090,952 | 472,510 | 579,803 | 944,833 |
| | 10,327,901 | 9,545,706 | 6,220,846 | 8,287,213 | 11,059,039 |

*Open-hearth steel ingots and castings manufactured in the United States, 1912–1916, in gross tons.*

| State. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| New England States | 214,325 | 195,419 | 137,962 | 191,582 | 278,768 |
| New York and New Jersey | 792,201 | 996,312 | 719,227 | 1,266,017 | 1,872,258 |
| Pennsylvania | 12,408,109 | 12,522,227 | 9,854,038 | 13,245,393 | 16,030,251 |
| Ohio | 2,565,343 | 2,726,219 | 2,592,778 | 3,521,404 | 5,057,751 |
| Indiana | 2,001,937 | 2,180,106 | 1,628,840 | 2,504,427 | 3,243,961 |
| Illinois | 1,235,166 | 1,264,854 | 896,610 | 1,169,657 | 1,812,169 |
| Other States | 1,563,642 | 1,714,794 | 1,345,229 | 1,780,622 | 3,120,269 |
| | 20,780,723 | 21,599,931 | 17,174,684 | 23,679,102 | 31,415,427 |

According to these tables there was an increase of 33 per cent in the total production of steel in 1916 compared with that of 1915, and practically the same per cent of increase for both open-hearth and Bessemer steels. Of the total output in 1916, 73 per cent was represented by open-hearth steel and 26 per cent by Bessemer steel, the production of all other classes of steel being less than 1 per cent of the total.

## PRODUCTION OF ELECTRIC STEEL.

The production of steel by the electric process in 1916 amounted to 168,918 gross tons, as compared with 69,412 tons in 1915, an increase of 99,506 tons, or more than 143 per cent. The following table gives the production of electric steel ingots and castings since 1909. In 1908 there were 55 tons of electric steel produced, but this quantity was included with open-hearth steel for that year.

In the total production of electric steel in 1915 are included 27,944 tons of steel ingots and castings which were treated with ferrovanadium, ferrotitanium, ferrochrome, and other alloys, of which 27,848 tons were ingots and 96 tons were castings. In 1916 the production of similarly treated steel amounted to about 71,129 tons, 70,203 tons of ingots, and 926 tons of castings.

On December 31, 1916, the number of completed plants which were equipped for the manufacture of steel by the electric process was 57, as compared with 34 plants at the close of 1915, a gain of 23 plants. The statistics of electric steel have been furnished by the bureau of statistics of the American Iron and Steel Institute.

*Steel electrically manufactured in the United States, 1909 to 1916, in gross tons.*

| Year. | Ingots. | Castings. | Total. |
|---|---|---|---|
| 1909 | 13,456 | 306 | 13,762 |
| 1910 | 50,821 | 1,320 | 52,141 |
| 1911 | 27,227 | 1,878 | 29,105 |
| 1912 | 14,147 | 4,162 | 18,309 |
| 1913 | 20,973 | 9,207 | 30,180 |
| 1914 | 15,458 | 8,551 | 24,009 |
| 1915 | 46,348 | 23,064 | 69,412 |
| 1916 | 126,048 | 42,870 | 168,918 |

## TOTAL DOMESTIC PRODUCTION OF STEEL.

*Steel produced in the United States, 1810–1916, in gross tons.*

| Year. | Bessemer. | Open-hearth. | Crucible. | Other Steel. | Total. |
|---|---|---|---|---|---|
| 1810 | | | 917 | | 917 |
| 1860 | | | 11,838 | | 11,838 |
| 1863 | | | 8,075 | | 8,075 |
| 1864 | | | 9,258 | | 9,258 |
| 1865 | | | 13,627 | | 13,627 |
| 1866 | | | 16,940 | | 16,940 |
| 1867 | 2,679 | | 16,964 | | 19,643 |
| 1868 | 7,589 | | 19,197 | | 26,786 |
| 1869 | 10,714 | 893 | 19,643 | | 31,250 |
| 1870 | 37,500 | 1,339 | 29,911 | | 68,750 |
| 1871 | 40,179 | 1,785 | 31,250 | | 73,214 |
| 1872 | 107,239 | 2,679 | 26,125 | 6,911 | 142,954 |
| 1873 | 152,368 | 3,125 | 31,059 | 12,244 | 198,796 |
| 1874 | 171,369 | 6,250 | 32,436 | 5,672 | 215,727 |
| 1875 | 335,283 | 8,080 | 35,180 | 11,256 | 389,799 |
| 1876 | 469,039 | 19,187 | 35,163 | 9,202 | 532,191 |
| 1877 | 500,624 | 22,349 | 36,098 | 10,647 | 569,618 |
| 1878 | 653,773 | 32,255 | 38,309 | 7,640 | 731,977 |
| 1879 | 829,439 | 50,259 | 50,696 | 4,879 | 935,273 |
| 1880 | 1,074,262 | 100,851 | 64,664 | 7,558 | 1,247,335 |
| 1881 | 1,374,247 | 131,202 | 80,145 | 2,720 | 1,588,314 |
| 1882 | 1,514,687 | 143,341 | 75,973 | 2,691 | 1,736,692 |
| 1883 | 1,477,345 | 119,356 | 71,835 | 4,999 | 1,673,535 |
| 1884 | 1,375,531 | 117,515 | 53,270 | 4,563 | 1,550,879 |
| 1885 | 1,519,430 | 133,376 | 57,599 | 1,515 | 1,711,920 |
| 1886 | 2,209,190 | 218,973 | 71,973 | 2,367 | 2,502,503 |
| 1887 | 2,936,033 | 322,069 | 75,375 | 5,594 | 3,339,071 |
| 1888 | 2,511,151 | 314,318 | 70,279 | 3,682 | 2,899,440 |
| 1889 | 2,930,204 | 374,543 | 75,865 | 5,120 | 3,385,732 |
| 1890 | 3,688,871 | 513,232 | 71,175 | 3,793 | 4,277,071 |
| 1891 | 3,247,017 | 579,753 | 72,586 | 4,484 | 3,904,240 |
| 1892 | 4,168,435 | 669,889 | 84,709 | 4,548 | 4,927,581 |
| 1893 | 3,215,086 | 737,890 | 62,613 | 2,806 | 4,019,995 |
| 1894 | 3,571,313 | 784,036 | 51,702 | 4,081 | 4,412,032 |
| 1895 | 4,909,128 | 1,137,182 | 67,666 | 858 | 6,114,834 |
| 1896 | 3,919,906 | 1,298,700 | 60,689 | 2,394 | 5,281,689 |
| 1897 | 5,475,315 | 1,608,671 | 69,959 | 3,012 | 7,156,957 |
| 1898 | 6,609,017 | 2,230,292 | 89,747 | 3,801 | 8,932,857 |
| 1899 | 7,586,354 | 2,947,316 | 101,213 | 4,974 | 10,639,857 |
| 1900 | 6,684,770 | 3,398,135 | 100,562 | 4,862 | 10,188,329 |
| 1901 | 8,713,302 | 4,656,309 | 98,513 | 5,471 | 13,473,595 |
| 1902 | 9,138,363 | 5,687,729 | 112,772 | 8,386 | 14,947,250 |
| 1903 | 8,502,829 | 5,829,911 | 102,434 | 9,804 | 14,534,978 |
| 1904 | 7,859,140 | 5,908,166 | 83,391 | 9,190 | 13,859,887 |
| 1905 | 10,941,375 | 8,971,376 | 102,233 | 8,963 | 20,023,947 |
| 1906 | 12,275,830 | 10,980,413 | 127,513 | 14,380 | 23,398,136 |
| 1907 | 11,667,549 | 11,549,736 | 131,234 | 14,075 | 23,362,594 |
| 1908 | 6,116,755 | 7,836,729 | 63,631 | 6,132 | 14,023,247 |
| 1909 | 9,330,783 | 14,493,936 | 107,355 | 22,947 | 23,955,021 |
| 1910 | 9,412,772 | 16,504,509 | 122,303 | 55,335 | 26,094,919 |
| 1911 | 7,947,854 | 15,598,650 | 97,653 | 31,949 | 23,676,106 |
| 1912 | 10,327,901 | 20,780,723 | 121,517 | 21,162 | 31,251,303 |
| 1913 | 9,545,706 | 21,599,931 | 121,226 | 34,011 | 31,300,874 |
| 1914 | 6,220,946 | 17,174,684 | 89,869 | 27,631 | 23,513,030 |
| 1915 | 8,287,213 | 23,679,102 | 113,782 | 70,939 | 32,151,036 |
| 1916 | 11,059,039 | 31,415,427 | 129,692 | 169,522 | 42,773,680 |

## FOREIGN TRADE IN STEEL.

The extraordinary development of the export trade in steel in the United States during 1915 and 1916 has warranted the insertion of a table showing, by classes, the exports of manufactured iron and steel from this country in 1914, 1915, and 1916. For comparison the imports are tabulated also. The figures were compiled from records of the Bureau of Foreign and Domestic Commerce.

In 1915 and 1916 the quantity of iron and steel exports (so far as recorded) increased 149 per cent and 66 per cent, respectively, but the total values increased 133 per cent and 136 per cent, respectively.

*Iron and steel imported into the United States, 1914, 1915, and 1916.*

| Article. | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| Scrap iron and steel | 34,839 | $277,818 | 79,982 | $761,719 | 116,039 | $1,140,704 |
| Bar iron | 15,015 | 625,365 | 8,474 | 417,491 | 7,701 | 647,393 |
| Ingots, blooms, slabs, etc., not elsewhere specified | 2,099 | 57,682 | 4,412 | 187,623 | 11,487 | 430,323 |
| Ingots, blooms, and slabs, billets and bars of steel, and steel in forms, not elsewhere specified | 38,090 | 2,885,365 | 10,586 | 1,753,978 | 17,792 | 2,809,319 |
| Hoop or band iron or steel for baling | [a] 648 | 23,702 | ..... | 28 | ..... | ..... |
| Rails for railway | 22,571 | 610,037 | 78,525 | 2,088,532 | 26,299 | 740,109 |
| Sheets and plates | 4,310 | 514,080 | 1,420 | 218,954 | 1,938 | 345,642 |
| Tin and terne plates | 15,411 | 1,049,297 | 2,350 | 196,328 | 1,129 | 214,574 |
| Wire rods | 6,954 | 373,615 | 5,317 | 331,724 | 4,625 | 509,559 |
| | 139,937 | 6,416,961 | 191,066 | 5,956,377 | 187,010 | 6,837,603 |
| Wire and articles made from wire | ..... | 1,205,456 | ..... | 640,521 | ..... | 652,889 |
| All other manufactures—free | ..... | 406,673 | ..... | 200,763 | ..... | 105,896 |
| All other manufactures—dutiable | ..... | 3,674,401 | ..... | 2,324,447 | ..... | 3,502,219 |
| | ..... | 5,286,530 | ..... | 3,165,731 | ..... | 4,261,004 |
| Grand total | ..... | 11,703,491 | ..... | 9,122,108 | ..... | 11,098,607 |

[a] Beginning July 1, 1914.

*Iron and steel exported from the United States, 1914, 1915, and 1916.*

| Article. | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| Scrap and old, fit only for manufacture | 33,134 | $386,208 | 79,361 | $1,111,254 | 212,765 | $3,689,675 |
| Bar iron | 5,226 | 203,835 | 39,740 | 1,471,466 | 74,069 | 3,913,849 |
| Bars or rods (of steel), wire rods | 61,856 | 1,810,389 | 165,015 | 4,713,109 | 158,284 | 8,109,111 |
| All other | 123,008 | 4,612,197 | 425,678 | 16,412,440 | 774,455 | 47,670,406 |
| Billets, ingots, and blooms, not elsewhere specified | 50,496 | 1,103,702 | 560,704 | 14,176,528 | 1,504,562 | 90,095,601 |
| Bolts and nuts | 15,127 | 1,234,440 | 23,536 | 1,896,842 | 29,227 | 3,132,897 |
| Hoop and bands | 9,954 | 457,451 | 29,249 | 1,433,879 | 43,208 | 3,251,882 |
| Horseshoes | 5,903 | 748,136 | 15,863 | 2,741,724 | 7,806 | 1,007,198 |
| Cut nails | 3,423 | 142,285 | 4,236 | 190,667 | 4,752 | 312,195 |
| Railroad spikes | 6,915 | 258,808 | 13,256 | 591,752 | 23,852 | 1,489,091 |
| Wire nails | 36,124 | 1,603,904 | 91,584 | 4,371,072 | 150,173 | 10,794,418 |
| All other (including tacks) | 3,183 | 401,319 | 9,251 | 1,085,416 | 12,353 | 1,637,051 |
| Cast-iron pipes and fittings | 38,418 | 1,462,670 | 47,022 | 2,128,025 | 70,223 | 3,988,293 |
| Wrought-iron pipes and fittings | 56,717 | 3,355,120 | 129,966 | 8,081,416 | 158,350 | 13,195,696 |
| Radiators and cast-iron house-heating boilers | 3,572 | 278,775 | 2,291 | 183,523 | 2,424 | 232,845 |
| Rails for railways, of steel | 174,680 | 5,103,918 | 391,379 | 12,095,170 | 540,878 | 20,417,582 |
| Galvanized iron and steel plates | 40,463 | 2,723,971 | 75,905 | 5,381,303 | 85,304 | 8,350,005 |
| Iron sheets and plates, all other | 7,555 | 404,213 | 25,543 | 1,221,699 | 46,499 | 3,136,262 |
| Steel plates | 111,642 | 4,198,106 | 223,806 | 8,037,551 | 276,034 | 16,499,757 |
| Steel sheets | 120,436 | 5,110,206 | 94,349 | 3,726,933 | 107,721 | 6,546,814 |
| Structural iron and steel | 182,395 | 6,961,636 | 232,139 | 8,960,411 | 300,594 | 17,541,862 |
| Tin and terne plates | 59,549 | 4,337,779 | 154,641 | 11,501,995 | 227,391 | 21,352,177 |
| Barbed wire | 93,846 | 4,633,348 | 248,611 | 13,933,234 | 418,882 | 31,230,905 |
| All other wire | 87,022 | 3,935,241 | 224,972 | 11,900,373 | 264,142 | 20,994,035 |
| | 1,330,644 | 55,467,657 | 3,308,097 | 137,347,782 | 5,493,898 | 338,589,607 |
| Axes | ..... | 751,313 | ..... | 588,443 | ..... | 722,520 |
| Hammers and hatchets | ..... | 265,682 | ..... | 509,824 | ..... | 366,161 |
| Railway-track material (except rails and spikes, switches, frogs, fishplates, splices, bars, etc.) | ..... | 1,775,391 | ..... | 4,857,047 | ..... | 6,540,187 |
| Saws | ..... | 1,158,122 | ..... | 1,294,447 | ..... | 2,923,055 |
| Shovels and spades | ..... | 263,733 | ..... | 352,727 | ..... | 666,407 |
| All other tools | ..... | 6,306,382 | ..... | 8,676,483 | ..... | 12,716,778 |
| | ..... | 10,520,623 | ..... | 16,278,971 | ..... | 23,935,108 |
| Grand total | ..... | 65,988,280 | ..... | 153,626,753 | ..... | 362,524,715 |

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# GOLD, SILVER, COPPER, LEAD, AND ZINC IN IDAHO.

(MINES REPORT.)

By C. N. GERRY.

## PRODUCTION.

### GENERAL STATEMENT.

The value of the mine production of gold, silver, copper, lead, and zinc in Idaho in 1916 was $48,767,783, an increase of 46 per cent over the value in 1915. Though the gold decreased slightly, the other metals increased distinctly. There were record productions of silver, lead, and zinc, and the aggregate value of the metal output was far greater than that of any previous year. The total value was augmented by greatly increased prices for metals.

The production of the State from the discovery of placer gold to the end of 1916 is given in the table below. The total[1] to 1914, inclusive, has been previously given by periods. It shows that the State has been an important producer of the five metals, which have a total value of nearly $563,000,000. Of this total, lead represents $246,165,726, or nearly 44 per cent; silver, $142,867,667, or more than 25 per cent; gold, $130,106,160, or more than 23 per cent; copper, $17,424,503, or more than 3 per cent; and zinc, $26,153,996, or nearly 5 per cent. The value of the mine production in 1916 exceeded the combined total value of zinc and copper from 1863 to the end of 1916.

*Mine production of gold, silver, copper, lead, and zinc in Idaho in 1915 and 1916.*

| Year. | Number of producers | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 412 | 2,408,846 | $1,179,731 | 11,769,128 | 6,978,713 | 345,999,466 | 70,153,234 | $ 33,328,930 |
| 1916 | 418 | 2,718,045 | 1,115,810 | 12,300,873 | 8,478,281 | 375,081,781 | 86,505,219 | 48,767,783 |
| Increase or decrease, 1916 | ..... | + 309,199 | − 63,921 | + 531,745 | +1,499,568 | +29,082,315 | +16,351,985 | +15,438,853 |
| Total 1863-1916 | ..... | ..... | 130,106,160 | 212,676,617 | 108,537,355 | 5,377,788,731 | 261,364,504 | 562,718,052 |

The table giving the separation according to source of metals shows a distinct increase in recoveries from lead-zinc ore and dry or siliceous ore, but a decrease in the placer output of gold. Ore formerly producing only lead concentrate is now yielding a zinc concentrate as well as a lead concentrate. The quantity of lead-zinc ore is therefore much greater.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 598, 1915.

*Ore and metals produced in Idaho in 1916.*

| Source of production. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Placers | 162 | ..... | 21,724.87 | 4,712 | ..... | ..... | ..... |
| Dry or siliceous | 98 | 71,083 | 25,496.72 | 112,519 | 40,391 | 114,994 | ..... |
| Copper ore | 41 | 113,050 | 3,619.47 | 218,598 | 6,583,043 | ..... | ..... |
| Lead ore | 99 | 1,373,579 | 2,572.87 | 8,227,936 | 1,466,389 | 257,016,676 | ..... |
| Zinc ore | 16 | 23,158 | 4.01 | 18,228 | ..... | 686,195 | 11,301,022 |
| Copper-lead ore | 2 | 22 | 5.66 | 351 | 2,154 | 11,647 | ..... |
| Lead-zinc ore | 18 | 1,136,553 | 553.70 | 3,718,529 | 386,304 | 117,252,209 | 75,204,197 |
| | ..... | 2,718,045 | 53,977.30 | 12,300,873 | 8,478,281 | 375,081,781 | 86,505,219 |

## ORE.

The quantity of ore sold or treated in Idaho in 1916 increased 309,199 tons, or nearly 13 per cent. Most of the ore sold or treated was lead ore and lead-zinc ore, the former being more than 50 per cent of the total and the latter nearly 42 per cent. Copper ore represented more than 4 per cent of the total; siliceous ore, nearly 3 per cent; and zinc ore and copper-lead ore less than 1 per cent. Much of the lead ore contains zinc that is not saved, but concentration improvements are now making a better saving of both zinc and lead. The total ore mined and treated had an average value per ton in gold and silver of $3.22. The average values in gold and silver for each kind of ore are shown at the foot of the following table. The siliceous ore sold or treated averaged per ton as follows: Gold, $7.35; silver, 1.57 ounces; with a trace of copper and lead. The siliceous ore included 69,443 tons of gold ore, averaging per ton $7.47 in gold and 0.41 ounce of silver; 447 tons of gold and silver ore, averaging per ton $10.51 in gold and 21.75 ounces of silver; and 1,793 tons of silver ore, averaging per ton $2.32 in gold, 41.35 ounces of silver, 15 pounds of copper, and 13 pounds of lead. The copper ore averaged per ton 66 cents in gold and 1.93 ounces of silver, and contained 2.91 per cent of copper. The averages of copper ore and concentrate shipped, as well as those of lead and zinc ores, are given after the tables showing contents of crude ore and concentrates. Lead ore as mined averaged 3.8 cents in gold and 5.99 ounces of silver per ton, and contained 0.05 per cent of copper and 9.35 per cent of lead. The total zinc ore mined or treated averaged per ton 0.3 cent in gold and 0.79 ounce of silver, and contained 1.48 per cent lead and 24.39 per cent of recoverable zinc. Copper-lead ore averaged per ton $5.32 in gold and 15.95 ounces of silver, and contained 4.89 per cent of copper and 26.47 per cent of lead. Lead-zinc ore averaged per ton 1 cent in gold and 3.27 ounces of silver, and contained 0.16 per cent copper, 5.16 per cent lead, and 3.30 per cent of recoverable zinc.

The output of siliceous ore, copper ore, and lead-zinc ore increased considerably.

*Ore sold or treated in Idaho in 1916, in short tons.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|
| Adams | 508 | 368 | | | | | 876 |
| Bannack | | 39 | 18 | | | | 57 |
| Bear Lake | | 59 | 3 | | | | 62 |
| Blaine | 1,418 | 109 | 6,055 | 323 | | 1,208 | 9,113 |
| Boise | 18,375 | 94 | | | 2 | | 18,471 |
| Bonner | 1,242 | 14 | 454 | | 20 | | 1,730 |
| Boundary | | 16 | 10,236 | | | | 10,252 |
| Cassia | 73 | | 41 | 38 | | | 152 |
| Clearwater | 15 | | | | | | 15 |
| Custer | 1 | 74,912 | 3,414 | | | | 78,327 |
| Elmore | 39,285 | | | | | | 39,285 |
| Fremont | | 369 | 11,305 | | | | 11,674 |
| Gem | 357 | | | | | | 357 |
| Idaho | 6,748 | | | | | | 6,748 |
| Lemhi | 2,713 | 314 | 21,018 | | | | 24,045 |
| Owyhee | 556 | | | | | | 556 |
| Shoshone | 392 | 36,756 | 1,321,035 | 22,797 | | 1,135,345 | 2,516,325 |
| | [a]71,683 | 113,050 | 1,373,579 | 23,158 | 22 | 1,136,553 | 2,718,045 |
| Average value per ton in gold and silver | $8.38 | $1.93 | $3.98 | $0.52 | $15.82 | $2.16 | $3.22 |

[a] Includes 69,443 tons of gold ore, 447 tons of gold and silver ore, and 1,793 tons of silver ore.

Approximately 2.5 per cent of the ore (69,773 tons) was treated in gold and silver mills in 1916, against 51,099 tons in 1915. Bullion from this ore treated by amalgamation or cyanidation was valued at $478,133, or $6.85 a ton of ore. Elmore County took the lead in output of bullion, as the Atlanta camp was again active. Ore treated by amalgamation—66,304 tons—gave good results in Elmore, Boise, and Idaho counties, and cyanidation was used to advantage in Elmore and Boise counties. At these mills during 1916 there were 1,183 pounds of mercury and 4,631 pounds of potassium and sodium cyanide consumed. The average consumption of quicksilver was 0.018 pound per ton of ore amalgamated and 0.039 pound per ounce of gold and silver bullion saved. The cyanide consumption was 1.33 pounds per ton of ore treated and 0.38 pound per ounce of gold and silver bullion recovered.

*Gold and silver produced in mills in Idaho in 1916.*

| County. | Ore. | Bullion recovered from ore by— | | | | Total value. |
|---|---|---|---|---|---|---|
| | | Amalgamation. | | Cyanidation. | | |
| | | Gold. | Silver. | Gold. | Silver. | |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | |
| Adams | 508 | | | 122.94 | 16 | $2,551 |
| Blaine | [a]1,321 | 614.21 | 262 | | | 12,869 |
| Boise | [b]18,359 | 4,191.28 | 1,017 | 1,910.93 | 538 | 127,167 |
| Clearwater | 15 | 7.98 | 3 | | | 167 |
| Elmore | 39,285 | 7,176.52 | 3,571 | 2,211.57 | 4,576 | 199,430 |
| Gem | 300 | 27.89 | 10 | | | 584 |
| Idaho | [c]6,725 | 4,993.72 | 2,125 | | | 104,627 |
| Lemhi | [d]2,713 | 755.87 | 212 | 26.13 | 2 | 16,306 |
| Owyhee | [e]547 | 316.02 | 5,329 | 124.65 | 2,759 | 14,432 |
| | 69,773 | 18,083.49 | 12,529 | 4,396.22 | 7,891 | 478,133 |

[a] Also yielded 34 tons of concentrates.
[b] Also yielded 993 tons of concentrates.
[c] Also yielded 15 tons of concentrates.
[d] Also yielded 5 tons of concentrates.
[e] Also yielded 3 tons of concentrates.

Nearly 88 per cent of the ore, or 2,387,881 tons, was concentrated. Concentrates from this ore, from 7,273 tons of old tailings treated, and from a small quantity treated in gold and silver mills aggregated 386,359 tons, valued at $34,983,145, or $90.55 a ton in 1916, against $73.33 a ton in 1915. The concentrates were largely from the Coeur d'Alene region, and the ratio was 6.2 tons of ore to 1 ton of concentrate. About 73 per cent of the total was lead concentrate, nearly 26 per cent lead-zinc concentrate, and less than 1 per cent was zinc concentrate, copper concentrate, and siliceous concentrate. There was good increase in lead concentrate and lead-zinc concentrate. Material from certain mines, classed as zinc concentrate in 1915, contained sufficient lead in 1916 to be classed as lead-zinc concentrate. Shoshone County shipped an average of 31,664 tons of concentrates of various kinds per month. The crude ore shipped, which was 12,275 tons per month, being added gives the Coeur d'Alene region average monthly shipments of 43,939 tons of concentrates and crude ore, against 35,390 tons in 1915.

*Mine production of metals from Idaho concentrates in 1916.*

**By counties.**

| County. | Ore to concentrating mills. | Concentrates produced. | | | | | | Total value of concentrates. |
|---|---|---|---|---|---|---|---|---|
| | | Quantity. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | |
| | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Blaine | 3,757 | 538 | 242.61 | 31,793 | 2,503 | 306,854 | 45,610 | $53,836 |
| Boise | ..... | 993 | 2,338.21 | 13,518 | 13,032 | 91,462 | ..... | 66,747 |
| Bonner | 454 | 73 | ..... | 943 | 160 | 111,225 | ..... | 8,334 |
| Boundary | 9,558 | 1,593 | 5.10 | 34,473 | 1,322 | 1,757,057 | ..... | 144,348 |
| Custer | 915 | 61 | 330.60 | 813 | 30,988 | ..... | ..... | 14,993 |
| Fremont | 11,266 | 3,077 | ..... | 36,136 | 7,958 | 3,302,525 | ..... | 253,609 |
| Idaho | ..... | 15 | 148.20 | 61 | ..... | ..... | ..... | 3,104 |
| Lemhi | 180 | 41 | 139.07 | 495 | 61,190 | ..... | ..... | 18,254 |
| Owyhee | ..... | 3 | 17.13 | 3,258 | ..... | ..... | ..... | 2,498 |
| Shoshone | 2,361,751 | 379,965 | 1,387.93 | 8,194,986 | 1,662,150 | 267,937,682 | 75,371,949 | 34,417,422 |
| | 2,387,881 | 386,359 | 4,608.75 | 8,316,476 | 1,779,303 | 273,506,805 | 75,417,559 | 34,983,145 |

**By kinds of concentrates.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dry or siliceous | 622 | 2,239.63 | 12,091 | 1,460 | 2,001 | ..... | $54,751 |
| Copper | 1,665 | 477.57 | 29,838 | 643,042 | ..... | ..... | 187,694 |
| Lead | 282,770 | 1,876.99 | 7,853,260 | 1,134,801 | 261,252,361 | ..... | 23,511,820 |
| Zinc | 1,526 | 10.56 | 4,863 | ..... | 48,730 | 1,053,937 | 148,009 |
| Lead-zinc | 99,776 | 4.00 | 416,424 | ..... | 12,203,713 | 74,363,622 | 11,080,871 |

The concentrates had the following average contents: Siliceous concentrates contained $74.43 in gold and 19.43 ounces of silver, or $88.02 per ton. Copper concentrates contained $5.93 in gold and 17.92 ounces of silver per ton, and also 19.31 per cent copper, a total value per ton of $112.72. Lead concentrates averaged 14 cents in gold and 27.77 ounces of silver per ton, and 0.2 per cent copper and 46.19 per cent lead, or a total value per ton of $83.15. Zinc concentrates averaged 14 cents in gold and 3.19 ounces of silver per ton,

1.59 per cent of lead, and 34.53 per cent recoverable zinc, or a total value per ton of $96.99. Lead-zinc concentrates averaged 4.17 ounces of silver per ton, 6.12 per cent of lead, and 37.26 per cent of recoverable zinc, or a total value per ton of $111.05. Averages for concentrates, as well as for shipping ore, from 1911 to 1914 were given in a previous report.[1]

Of the total ore, 249,964 tons, or more than 9 per cent, was shipped crude to smelters. A large part of this ore in Shoshone County is picked from the belts as it comes into the mills. As in past years, Shoshone County was foremost in shipments of crude ore, and Custer and Lemhi counties ranked next. In 1916 all of this ore went to plants outside the State, but in 1917 part of the lead products will be smelted at the Bunker Hill smelter, at Kellogg. The total value of the first-class ore was $12,820,562, or $51.29 a ton. There was a marked increase in all kinds of shipping products. The most pronounced increase was in lead ore in the Coeur d'Alene region and copper ore from mines near Mackay, in Custer County. More than 63 per cent of the crude ore shipped was lead ore, 30 per cent was copper ore, and more than 5 per cent was zinc ore. The combined value of the concentrates and the crude ore shipped, all of which went to distant smelters, was $47,803,707. The crude ore smelted was principally sulphide in character. A close separation of oxidized and sulphide portions, with average content per ton, is as follows: Copper ore shipped consisted of 38,866 tons of oxidized and carbonate ore, averaging 83 cents in gold and 1.91 ounces of silver per ton and also 4.03 per cent of copper, or a total value per ton of $21.91, and of 37,043 tons of sulphide ore, averaging 88 cents in gold and 3.07 ounces of silver per ton and also 3.77 per cent of copper, or a total value per ton of $21.46. There was a greater difference in the lead ore, for the oxidized portion—27,462 tons—averaged 72 cents in gold and 14.51 ounces of silver per ton, 0.35 per cent of copper, and 23.80 per cent lead, or a total value per ton of $44.82; and the sulphide lead ore shipped—130,508 tons—averaged 11 cents in gold and 24.95 ounces of silver per ton, 0.2 per cent of copper, and 33.48 per cent lead, or a total value per ton of $63.70. A small quantity of oxidized zinc ore averaged 24.41 per cent of recoverable zinc, and 12,815 tons of sulphide ore shipped contained 40.87 per cent recoverable zinc and 2.54 per cent lead. All the lead-zinc ore and copper-lead ore shipped was sulphide.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 601, 1915.

*Mine production of metals from Idaho crude ore shipped to smelters in 1916.*

By counties.

| County. | Quantity. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Adams | 368 | 28.52 | 2,288 | 132,637 | ..... | ..... | $34,725 |
| Bannock | 57 | ..... | 184 | 6,343 | 9,234 | ..... | 2,318 |
| Bear Lake | 62 | ..... | 8 | 4,604 | 3,851 | ..... | 1,404 |
| Blaine | 1,143 | 11.46 | 23,743 | 16,685 | 368,443 | 202,769 | 72,556 |
| Boise | 112 | 19.83 | 4,450 | 10,228 | 894 | ..... | 5,916 |
| Bonner | 1,276 | 152.43 | 30,176 | 25,157 | 12,279 | ..... | 30,043 |
| Boundary | 694 | 4.00 | 13,044 | 1,199 | 659,078 | ..... | 54,437 |
| Cassia | 152 | 55.24 | 3,461 | 2,239 | 39,886 | 18,557 | 9,208 |
| Custer | 77,150 | 2,979.12 | 167,948 | 5,488,396 | 743,842 | ..... | 1,573,564 |
| Fremont | 408 | ..... | 429 | 108,280 | 32,341 | ..... | 29,150 |
| Gem | 57 | 43.42 | 1,938 | 190 | ..... | ..... | 2,219 |
| Idaho | 23 | 80.11 | 120 | 739 | ..... | ..... | 1,917 |
| Lemhi | 21,152 | 971.02 | 246,567 | 155,143 | 11,208,985 | ..... | 993,899 |
| Owyhee | 9 | 33.64 | 5,162 | ..... | ..... | ..... | 4,092 |
| Shoshone | 147,301 | 754.56 | 3,444,837 | 708,460 | 88,296,244 | 10,866,334 | 10,005,112 |
| | 249,964 | 5,133.35 | 3,944,355 | 6,660,300 | 101,375,077 | 11,087,660 | 12,820,562 |

By kinds of ore.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dry or siliceous | 1,902 | 344.09 | 75,145 | 27,354 | 23,487 | ..... | $64,907 |
| Copper | 75,909 | 3,141.90 | 188,335 | 5,924,652 | ..... | ..... | 1,646,338 |
| Lead | 157,970 | 1,635.11 | 3,654,390 | 706,140 | 100,463,507 | ..... | 9,544,089 |
| Zinc | 12,853 | .67 | 16,927 | ..... | 651,185 | 10,494,093 | 1,462,292 |
| Copper-lead | 22 | 5.67 | 351 | 2,154 | 11,647 | ..... | 1,682 |
| Lead-zinc | 1,308 | 5.91 | 9,207 | ..... | 225,161 | 593,567 | 101,254 |

The crude ore shipped had the following averages: Siliceous ore averaged $3.74 in gold and 39.51 ounces of silver per ton, 0.72 per cent of copper, and 0.62 per cent lead, or a total value per ton of $34.13; copper ore, 86 cents in gold and 2.48 ounces of silver per ton and 3.90 per cent copper, or a total value per ton of $21.69; lead ore, 21 cents in gold and 23.13 ounces of silver per ton, 0.23 per cent of copper, and 31.79 per cent lead, or a value per ton of $60.42; zinc ore, 1.32 ounces of silver per ton, 2.53 per cent lead, and 40.82 per cent of recoverable zinc, or a total value per ton of $113.77; lead-zinc ore, 9 cents in gold and 7.04 ounces of silver per ton, 8.60 per cent lead, and 22.68 per cent of recoverable zinc, or a total value per ton of $77.41; copper-lead ore, $5.32 in gold and 15.95 ounces of silver per ton, 4.89 per cent of copper, and 26.47 per cent of lead.

## GOLD.

The mine production of gold in 1916 was 53,977.30 fine ounces, valued at $1,115,810, a decrease of $63,921, or more than 5 per cent. Boise County was the largest producer of gold, followed by Elmore, Idaho, Lemhi, and Custer counties. Increase in Elmore and Idaho was offset by decrease in Boise, Lemhi, and Owyhee. The lode mines, 256 in number, produced gold valued at $666,717; and 162 placers produced gold valued at $449,093, against 186 placers and $584,890 in 1915. Of the placer gold, $327,696, or 73 per cent, was won by 4 dredges; $185 by drift mines; and $121,212 by hydraulic or sluicing mines. The dredge output in 1916 decreased $158,845 from that of 1915, but gold from sluicing and hydraulicking increased

$24,849. Of the total gold, more than 40 per cent came from placers, more than 47 per cent from siliceous ore, nearly 5 per cent from lead ore, nearly 7 per cent from copper ore, and 1 per cent from lead-zinc ore. Siliceous ores contained $7.35 a ton in gold, copper ore, 66 cents; lead ore, 3.8 cents; copper-lead ore, $5.32; and lead-zinc ore, 1 cent. Snake River in various counties produced $5,824 in gold and 12 ounces of silver. A better production of gold from amalgamation and cyanidation mills, both in 1915 and 1916, followed a period of meager production from those sources. In 1916 bullion recovered in these mills contained 22,479.71 ounces of gold, or nearly 42 per cent of the total, against 19,687.76 ounces in 1915. Amalgamation won 18,083.49 ounces of gold and cyanidation 4,396.22 ounces. Concentrates of all kinds contained only 4,608.75 ounces of gold, or nearly 9 per cent of the total gold, an average per ton of 25 cents. Crude ore shipped to smelters contained 5,133.35 ounces of gold, or nearly 10 per cent of the total. Various sulphide shipping ores contained 2,264.85 ounces of gold and oxidized ores contained 2,868.50 ounces. A statement of the dredges operated since 1897 and their output by years was given in a former report.[1] A total in gold of $3,722,056 has been recovered by dredges.

*Mine production of gold in Idaho in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Ada | 128.63 | | | | | | | 128.63 |
| Adams | | 122.93 | 28.53 | | | | | 151.46 |
| Benewah | 392.08 | | | | | | | 392.08 |
| Bingham | 2.32 | | | | | | | 2.32 |
| Blaine | | 754.25 | 1.61 | 114.24 | 0.67 | | 28.13 | 898.90 |
| Boise | 14,278.90 | 8,445.46 | 13.10 | | | 1.69 | | 22,739.15 |
| Bonner | | 147.55 | .91 | | | 3.97 | | 152.43 |
| Bonneville | 254.84 | | | | | | | 254.84 |
| Boundary | | | | 9.00 | | | | 9.00 |
| Canyon | 82.62 | | | | | | | 82.62 |
| Cassia | | 13.32 | | 41.92 | | | | 55.24 |
| Clearwater | 1,263.17 | 7.98 | | | | | | 1,271.15 |
| Custer | 199.35 | 4.53 | 3,284.59 | 20.60 | | | | 3,509.07 |
| Elmore | 238.68 | 9,388.09 | | | | | | 9,626.77 |
| Gem | 5.61 | 71.31 | | | | | | 76.92 |
| Gooding | 11.76 | | | | | | | 11.76 |
| Idaho | 1,033.92 | 5,222.03 | | | | | | 6,255.95 |
| Latah | 35.99 | | | | | | | 35.99 |
| Lemhi | 3,577.67 | 811.33 | 158.02 | 922.74 | | | | 5,469.76 |
| Nez Perce | 1.98 | | | | | | | 1.98 |
| Owyhee | 8.95 | 491.44 | | | | | | 500.39 |
| Power | 78.37 | | | | | | | 78.37 |
| Shoshone | 104.97 | 16.50 | 132.71 | 1,464.37 | 3.34 | | 525.57 | 2,247.46 |
| Twin Falls | 25.06 | | | | | | | 25.06 |
| | 21,724.87 | [a] 25,496.72 | 3,619.47 | 2,572.87 | 4.01 | 5.66 | 553.70 | 53,977.30 |

[a] Includes 25,068.38 ounces from gold ore, 227.19 ounces from gold and silver ore, and 201.15 ounces of silver ore.

## SILVER.

The mine production of silver increased from 11,769,128 ounces, valued at $5,966,948, in 1915 to 12,300,873 ounces, valued at $8,093,974, in 1916, an increase of nearly 5 per cent in quantity and of 36 per cent in value. The main increase was in ores from Shoshone County, and smaller increases were recorded in Lemhi and Custer

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 604, 1915.

counties. A separation of the silver according to source shows that the largest part of the total silver yield, or 67 per cent, was from lead ore, 30 per cent from lead-zinc ore, nearly 2 per cent from copper ore, and less than 1 per cent from siliceous ore. Shoshone County produced nearly 95 per cent of the silver. Concentrates supplied nearly 68 per cent of the silver, crude ore contained 32 per cent, and gold and silver bullion contained only 0.16 per cent. Crude ore averaged 15.78 ounces a ton and concentrates 21.53 ounces a ton. The oxidized portion of the crude ore shipped contained 8.03 ounces of silver and the sulphide 18.69 ounces.

*Mine production of silver in Idaho in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|---|---|
| Ada | 30 | | | | | | | 30 |
| Adams | | 16 | 2,288 | | | | | 2,304 |
| Bannock | | | 94 | 90 | | | | 184 |
| Bear Lake | | | 4 | 4 | | | | 8 |
| Benewah | 46 | | | | | | | 46 |
| Blaine | | 799 | 243 | 64,888 | 567 | | 3,786 | 70,283 |
| Boise | 3,638 | 18,054 | 1,397 | | | 72 | | 23,161 |
| Bonner | | 29,889 | 8 | 943 | | 279 | | 31,119 |
| Bonneville | 6 | | | | | | | 6 |
| Boundary | | | 41 | 47,476 | | | | 47,517 |
| Canyon | 15 | | | | | | | 15 |
| Cassia | | 2,249 | | 1,212 | | | | 3,461 |
| Clearwater | 268 | 3 | | | | | | 271 |
| Custer | 86 | | 143,062 | 26,124 | | | | 169,272 |
| Elmore | 29 | 8,147 | | | | | | 8,176 |
| Fremont | | | 188 | 36,377 | | | | 36,565 |
| Gem | 3 | 1,948 | | | | | | 1,951 |
| Idaho | 266 | 2,306 | | | | | | 2,572 |
| Latah | 2 | | | | | | | 2 |
| Lemhi | 295 | 233 | 804 | 246,239 | | | | 247,571 |
| Owyhee | 5 | 16,508 | | | | | | 16,513 |
| Power | 5 | | | | | | | 5 |
| Shoshone | 18 | 32,367 | 70,469 | 7,804,583 | 17,061 | | 3,714,743 | 11,639,841 |
| | 4,712 | [a] 112,519 | 218,598 | 8,227,936 | 18,228 | 351 | 3,718,529 | 12,300,873 |

[a] Includes 28,657 ounces from gold ore, 9,721 ounces from gold and silver ore, and 74,141 ounces from silver ore.

## COPPER.

The mine production of copper increased from 6,978,713 pounds, valued at $1,221,275, in 1915 to 8,478,281 pounds, valued at $2,085,657 in 1916, an increase of more than 21 per cent in quantity and of 71 per cent in value. The production was less than that of 1913, when 9,592,966 pounds were produced, partly from the Snow Storm mine, in Shoshone County. Since that mine was abandoned Custer County has supplied most of the copper. The Empire property, near Mackay, is still the largest producer, but other mines near by are becoming important. Progress at the Richmond, Horst-Powell, and National Copper may make the Coeur d'Alene region a notable copper producer. About 77 per cent of the total output of copper was from copper ore, 17 per cent from lead ore, and nearly 5 per cent from lead-zinc ore. Crude ore supplied nearly 79 per cent of the total, and concentrates contained 21 per cent. Crude copper ore shipped averaged 3.90 per cent copper, and copper concentrates 19.31 per cent. Sulphide ore shipped contained 3.77 per cent of copper, and oxidized ore, 4.03 per cent. The average price of copper increased from 17.5 cents a pound in 1915 to 24.6 cents in 1916.

*Mine production of copper in Idaho in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|
| Adams | | 132,637 | | | | 132,637 |
| Bannock | | 6,343 | | | | 6,343 |
| Bear Lake | | 4,604 | | | | 4,604 |
| Blaine | 5 | 15,773 | 26,313 | | 426 | 42,517 |
| Boise | 13,101 | 10,017 | | 142 | | 23,260 |
| Bonner | 19,200 | 3,945 | 160 | 2,012 | | 25,317 |
| Boundary | | 1,199 | 1,322 | | | 2,521 |
| Cassia | | | 2,239 | | | 2,239 |
| Custer | | 5,519,386 | 15,347 | | | 5,534,733 |
| Fremont | | 108,170 | 8,068 | | | 116,238 |
| Gem | 190 | | | | | 190 |
| Idaho | 739 | | | | | 739 |
| Lemhi | | 87,388 | 128,945 | | | 216,333 |
| Shoshone | 7,156 | 693,581 | 1,283,995 | | 385,878 | 2,370,610 |
| | [a] 40,391 | 6,583,043 | 1,466,389 | 2,154 | 386,304 | 8,478,281 |

[a] Includes 13,776 pounds from gold ore, 130 pounds from gold and silver ore, and 26,485 pounds from silver ore.

## LEAD.

The mine production of lead increased from 345,999,466 pounds, valued at $16,261,975, in 1915 to 375,081,781 pounds, valued at $25,880,643, in 1916. The increase in quantity was more than 8 per cent and in value 59 per cent. The total establishes a new record for the State. Aside from Shoshone County, which supplied 95 per cent of the total, good productions came from Lemhi, Fremont, Boundary, and Blaine counties. Lead ore supplied more than 68 per cent of the total; lead-zinc ore, more than 31 per cent; and zinc ore, less than 1 per cent. The recoverable lead in all ores sold or treated averaged 6.89 per cent; that in lead ore, 9.35 per cent; and that in lead-zinc ore, 5.16 per cent. Crude lead ore shipped averaged 31.79 per cent of recoverable lead, and lead concentrates 46.19 per cent. Concentrates of all kinds produced nearly 73 per cent of the total. Lead concentrates had an average value per ton of $83.15. Crude ore shipped was the source of 27 per cent of the lead, and the lead ore shipped to smelter had an average value per ton of $60.42. Nearly all the lead in crude ore shipped was from sulphide ores, only 13,073,571 pounds coming from oxidized ores. The average price of lead for 1916 increased 2.2 cents over the price of 1915.

*Mine production of lead in Idaho in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Lead ore. | Zinc ore. | Copper-lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|
| Bannock | | 9,234 | | | | 9,234 |
| Bear Lake | | 3,851 | | | | 3,851 |
| Blaine | 4,916 | 815,928 | 4,269 | | 50,083 | 875,196 |
| Boise | 91,545 | | | 811 | | 92,356 |
| Bonner | 1,443 | 111,225 | | 10,836 | | 123,504 |
| Boundary | | 2,416,135 | | | | 2,416,135 |
| Cassia | 4,530 | 35,356 | | | | 39,886 |
| Custer | | 743,842 | | | | 743,842 |
| Fremont | | 3,331,866 | | | | 3,331,866 |
| Lemhi | | 11,208,985 | | | | 11,208,985 |
| Shoshone | 12,560 | 238,337,254 | 681,926 | | 117,202,186 | 356,233,926 |
| | [a] 114,994 | 257,016,676 | 686,195 | 11,647 | 117,252,269 | 375,081,781 |

[a] Includes 91,507 pounds from gold ore and 23,487 pounds from silver ore.

## ZINC.

The mine production of recoverable zinc increased from 70,153,234 pounds, valued at $8,699,001, in 1915 to 86,505,219 pounds, valued at $11,591,699, in 1916. This increase of more than 23 per cent in quantity and 33 per cent in value came almost entirely from the Coeur d'Alene region. The Consolidated Interstate Callahan property retained first place among the zinc producers of the State. The zinc output from Blaine County decreased, but shipments being made early in 1917 indicate an improvement. In 1904 zinc in ore was considered a detriment; in 1915 and 1916 the value of the zinc output in Idaho was greater than the combined value of the gold, silver, and copper of the State. Lead-zinc ore supplied 87 per cent and zinc ore 13 per cent of the zinc. Both the zinc concentrates and the crude zinc ore shipped are sulphide products, except the ore from Cassia County. From concentrates, both zinc and lead-zinc, 75,417,559 pounds of recoverable zinc were won, or 87 per cent of total; and from crude ore shipped, 11,087,660 pounds were won, or nearly 13 per cent of the total. Flotation has proved an aid in most of the concentration mills of Shoshone County. Roasting and magnetic separation were used at the Success and Frisco mills. The average price of metallic zinc was 13.4 cents in 1916, 1 cent more than the price in 1915.

*Mine production of recoverable zinc in Idaho in 1916, in dry pounds.*

| County. | Zinc ore. | Lead-zinc ore. | Total. |
|---|---|---|---|
| Blaine | 202,769 | 45,610 | 248,379 |
| Cassia | 18,557 | ..... | 18,557 |
| Shoshone | 11,079,696 | 75,158,587 | 86,238,283 |
| | 11,301,022 | 75,204,197 | 86,505,219 |

The sources of the ore and the actual assay in zinc, without deduction for losses in smelting, are shown below. There were 115,463 tons of zinc ore, zinc concentrates, lead-zinc ore, and lead-zinc concentrates shipped, of which the gross assay content was 101,738,293 pounds of zinc, or an average of 44.06 per cent. Most of the output came from the Beaver, Hunter, Lelande, Placer, Center, Summit, and Yreka districts in Shoshone County. In 1915 the shipments were 90,363 tons of zinc ore and concentrates, containing 82,521,106 pounds of zinc, or an average of 45.66 per cent.

*Zinc ore, lead-zinc ore, and concentrates produced from Idaho mines sold in 1916.*

| Classification. | County. | Quantity (short tons, dry weight). | Average assay of ore and concentrate (per cent of zinc).[a] |
|---|---|---|---|
| Sulphide zinc ore and concentrates | Blaine and Shoshone | 14,341 | 47.18 |
| Sulphide lead-zinc ore and concentrates | Shoshone | 101,084 | 43.62 |
| Carbonate zinc ore | Cassia | 38 | 28.73 |
| | | 115,463 | 44.06 |

[a] Actual zinc content.

## REDUCTION PLANTS.

In Idaho 79 milling plants of all kinds were in operation in 1916, against 75 active mills in 1915. Of these mills, 37 were concentration plants, 20 of which used flotation machines with other concentration devices and 2 used roasting and magnetic separation; 27 used amalgamation alone; 2 used cyanidation; 7 amalgamation and concentration; 2 amalgamation and cyanidation; 1 concentration and cyanidation; and 3 amalgamation, concentration, and cyanidation. No smelting plants were operated within the State. The nearest lead plant is at Northport, Wash. In 1917 ores will be smelted at Kellogg, in the western part of the Coeur d'Alene region.

## MINING INDUSTRY.

Idaho enjoyed a year of unusual prosperity in 1916, as shown in the profits of the mines of the Coeur d'Alene region. In 1914 profits were only $6,000,000, owing to the general depression at the beginning of the war. In 1915 prices improved and profits were nearly $10,000,000. In 1916 every effort was made to take advantage of the still higher prices and the profits were $12,000.000. Aside from dividends, there were other indications of better conditions. The State was free from labor dissensions, as workmen were content when wages were increased as the metal prices advanced. The sliding scale added $1,500,000 to the wages of about 5,000 men for 1916. The local smelting of ores, which has been the dream of Coeur d'Alene operators for many years, will be an accomplishment of 1917. Construction of the Bunker Hill smelter was begun the latter part of 1916. The completion of the electrolytic zinc plant at Great Falls provides a new market for the Coeur d'Alene material. There is a saving in freight, and even comparatively low-grade zinc material is purchased for concentration. A branch line of the Oregon-Washington Railroad & Navigation Co. was completed up Beaver Creek, connecting with the Murray branch at Idora spur. Notwithstanding much activity in Pine Creek, construction of the railroad to that section was not begun. Though Shoshone County is the important mining center, other districts of the State shared the substantial activity.

*Mine production of gold, silver, copper, lead, and zinc in Idaho in 1916.*

| County. | Gold. | | | | | Silver. | |
|---|---|---|---|---|---|---|---|
| | Placers. | | Deep mines. | | Total value. | | |
| | Quantity. | Value. | Quantity. | Value. | | Quantity. | Value. |
| | *Fine ounces.* | | *Fine ounces.* | | | *Fine ounces.* | |
| Ada | 128.63 | $2,659 | | | $2,659 | 30 | $20 |
| Adams | | | 151.46 | $3,131 | 3,131 | 2,304 | 1,516 |
| Bannock | | | | | | 184 | 121 |
| Bear Lake | | | | | | 8 | 5 |
| Benewah | 392.08 | 8,105 | | | 8,105 | 46 | 30 |
| Bingham | 2.32 | 48 | | | 48 | | |
| Blaine | | | 898.90 | 18,582 | 18,582 | 70,283 | 46,246 |
| Boise | 14,278.90 | 295,171 | 8,460.25 | 174,889 | 470,060 | 23,161 | 15,240 |
| Bonner | | | 152.43 | 3,151 | 3,151 | 31,119 | 20,476 |
| Bonneville | 254.84 | 5,268 | | | 5,268 | 6 | 4 |
| Boundary | | | 9.00 | 186 | 186 | 47,517 | 31,266 |
| Canyon | 82.62 | 1,708 | | | 1,708 | 15 | 10 |
| Cassia | | | 55.24 | 1,142 | 1,142 | 3,461 | 2,277 |
| Clearwater | 1,263.17 | 26,112 | 7.98 | 165 | 26,277 | 271 | 178 |
| Custer | 199.35 | 4,121 | 3,309.72 | 68,418 | 72,539 | 169,272 | 111,381 |
| Elmore | 238.68 | 4,934 | 9,388.09 | 194,069 | 199,003 | 8,176 | 5,380 |
| Fremont | | | | | | 36,565 | 24,060 |
| Gem | 5.61 | 116 | 71.31 | 1,474 | 1,590 | 1,951 | 1,284 |
| Gooding | 11.76 | 243 | | | 243 | | |
| Idaho | 1,033.92 | 21,373 | 5,222.03 | 107,949 | 129,322 | 2,572 | 1,693 |
| Latah | 35.99 | 744 | | | 744 | 2 | 1 |
| Lemhi | 3,577.67 | 73,957 | 1,892.09 | 39,113 | 113,070 | 247,571 | 162,902 |
| Nez Perce | 1.98 | 41 | | | 41 | | |
| Owyhee | 8.95 | 185 | 491.44 | 10,159 | 10,344 | 16,513 | 10,865 |
| Power | 78.37 | 1,620 | | | 1,620 | 5 | 3 |
| Shoshone | 104.97 | 2,170 | 2,142.49 | 44,289 | 46,459 | 11,639,841 | 7,659,016 |
| Twin Falls | 25.06 | 518 | | | 518 | | |
| | 21,724.87 | 449,093 | 32,252.43 | 666,717 | 1,115,810 | 12,300,873 | 8,093,974 |

| County. | Copper. | | Lead. | | Recoverable zinc content. | | Total value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Ada | | | | | | | $2,679 |
| Adams | 132,637 | $32,629 | | | | | 37,276 |
| Bannock | 6,343 | 1,560 | 9,234 | $637 | | | 2,318 |
| Bear Lake | 4,604 | 1,133 | 3,851 | 266 | | | 1,404 |
| Benewah | | | | | | | 8,135 |
| Bingham | | | | | | | 48 |
| Blaine | 42,517 | 10,459 | 875,196 | 60,388 | 248,379 | $32,283 | 168,958 |
| Boise | 23,260 | 5,722 | 92,356 | 6,373 | | | 497,395 |
| Bonner | 25,317 | 6,228 | 123,504 | 8,522 | | | 38,377 |
| Bonneville | | | | | | | 5,272 |
| Boundary | 2,521 | 620 | 2,416,135 | 166,713 | | | 198,785 |
| Canyon | | | | | | | 1,718 |
| Cassia | 2,239 | 551 | 39,886 | 2,752 | 18,557 | 2,486 | 9,208 |
| Clearwater | | | | | | | 26,455 |
| Custer | 5,534,733 | 1,361,544 | 743,842 | 51,325 | | | 1,596,789 |
| Elmore | | | | | | | 204,383 |
| Fremont | 116,238 | 28,594 | 3,334,866 | 230,106 | | | 282,760 |
| Gem | 190 | 47 | | | | | 2,921 |
| Gooding | | | | | | | 243 |
| Idaho | 739 | 182 | | | | | 131,197 |
| Latah | | | | | | | 745 |
| Lemhi | 216,333 | 53,218 | 11,208,985 | 773,420 | | | 1,102,610 |
| Nez Perce | | | | | | | 41 |
| Owyhee | | | | | | | 21,209 |
| Power | | | | | | | 1,623 |
| Shoshone | 2,370,610 | 583,170 | 356,233,926 | 24,580,141 | 86,238,283 | 11,555,930 | 44,424,716 |
| Twin Falls | | | | | | | 518 |
| | $8,478,281 | 2,085,657 | 375,081,781 | 25,880,643 | 86,505,219 | 11,591,699 | 48,767,783 |

*Producing placer mines and production of gold and silver in Idaho in 1915 and 1916.*

| County. | 1915 | | | | | | 1916 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hydraulic. | Dredge. | Drift. | Gold. | Silver. | Total value. | Hydraulic. | Dredge. | Drift. | Gold. | Silver. | Total value. |
| | | | | | *Fine ounces.* | | | | | | *Fine ounces.* | |
| Ada | 2 | .... | .... | $1,918 | 19 | $1,928 | 3 | .... | .... | $2,659 | 30 | $2,679 |
| Adams | 1 | .... | .... | 417 | 8 | 421 | .... | .... | .... | .... | .... | .... |
| Benewah | 2 | .... | .... | 4,858 | 26 | 4,871 | 2 | .... | .... | 8,105 | 46 | 8,135 |
| Bingham | 1 | .... | .... | 770 | 3 | 771 | 1 | .... | .... | 48 | .... | 48 |
| Blaine | 2 | .... | .... | 61 | .... | 61 | .... | .... | .... | .... | .... | .... |
| Boise | 33 | 1 | .... | 383,259 | 4,563 | 385,572 | 30 | 1 | 1 | 295,171 | 3,638 | 297,565 |
| Bonner | 2 | .... | .... | 186 | 2 | 187 | .... | .... | .... | .... | .... | .... |
| Bonneville | 4 | .... | .... | 4,512 | 7 | 4,516 | 2 | .... | .... | 5,268 | 6 | 5,272 |
| Canyon | 4 | .... | .... | 378 | 5 | 381 | 4 | .... | .... | 1,708 | 15 | 1,718 |
| Clearwater | 15 | 2 | .... | 28,041 | 335 | 28,236 | 15 | 1 | .... | 26,112 | 268 | 26,288 |
| Custer | 7 | .... | .... | 1,014 | 11 | 1,020 | 7 | .... | .... | 4,121 | 86 | 4,177 |
| Elmore | 13 | .... | .... | 6,687 | 87 | 6,731 | 10 | .... | .... | 4,934 | 29 | 4,953 |
| Gem | 2 | .... | .... | 257 | 3 | 258 | 2 | .... | .... | 116 | 3 | 118 |
| Gooding | 4 | .... | .... | 908 | 2 | 909 | 4 | .... | .... | 243 | .... | 243 |
| Idaho | 46 | 1 | 6 | 28,131 | 292 | 28,279 | 45 | .... | .... | 21,373 | 266 | 21,549 |
| Latah | 3 | .... | .... | 659 | 4 | 661 | 4 | .... | .... | 744 | 2 | 745 |
| Lemhi | 10 | 2 | .... | 118,123 | 449 | 118,351 | 9 | 2 | .... | 73,957 | 295 | 74,151 |
| Minidoka | 1 | .... | .... | 178 | 2 | 179 | .... | .... | .... | .... | .... | .... |
| Nez Perce | .... | .... | 1 | 51 | .... | 51 | 1 | .... | 1 | 41 | .... | 41 |
| Owyhee | 4 | .... | .... | 254 | 42 | 275 | 4 | .... | .... | 185 | 5 | 188 |
| Power | 2 | 1 | .... | 700 | 2 | 701 | 2 | .... | .... | 1,620 | 5 | 1,623 |
| Shoshone | 9 | .... | .... | 1,866 | 15 | 1,874 | 7 | .... | .... | 2,170 | 18 | 2,182 |
| Twin Falls | 5 | .... | .... | 1,662 | 8 | 1,666 | 4 | .... | .... | 518 | .... | 518 |
| | 172 | 7 | 7 | 584,890 | 5,935 | 587,899 | 156 | 4 | 2 | 449,093 | 4,712 | 452,193 |

*Ore sold or treated, deep mines producing, and average value of ores in Idaho.*

| County. | Ore sold or treated in 1916. | | Number of deep mines producing. | | Average total value per ton. [a] | | Average value per ton in gold and silver. [a] | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Increase or decrease. | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 |
| | *Short tons.* | *Short tons.* | | | | | | |
| Ada | .... | − 97 | 4 | .... | $12.16 | .... | $12.16 | .... |
| Adams | 876 | − 608 | 5 | 6 | 11.68 | $42.55 | 4.76 | $5.30 |
| Bannock | 57 | + 52 | 1 | 3 | 43.20 | 40.67 | .40 | 2.12 |
| Bear Lake | 62 | + 62 | .... | 3 | .... | 22.64 | .... | .08 |
| Blaine | 9,113 | − 1,447 | 33 | 44 | 16.27 | 18.54 | 6.59 | 7.11 |
| Boise | 18,471 | + 63 | 15 | 17 | 9.57 | 10.82 | 9.51 | 10.16 |
| Bonner | 1,730 | + 1,079 | 7 | 8 | 26.01 | 22.18 | 11.43 | 13.66 |
| Bonneville | .... | − 16 | 1 | .... | 11.25 | .... | 2.25 | .... |
| Boundary | 10,252 | + 40 | 1 | 2 | 14.86 | 19.39 | 3.25 | 3.07 |
| Cassia | 152 | + 11 | 3 | 3 | 54.44 | 60.58 | 13.59 | 22.49 |
| Clearwater | 15 | .... | 1 | 1 | 7.73 | 11.13 | 7.73 | 11.13 |
| Custer | 78,327 | + 23,523 | 14 | 21 | 18.11 | 20.33 | 2.85 | 2.29 |
| Elmore | 39,285 | + 23,786 | 11 | 5 | 4.74 | 5.08 | 4.74 | 5.08 |
| Fremont | 11,674 | + 705 | 1 | 8 | 23.34 | 24.22 | 1.68 | 2.06 |
| Gem | 357 | + 295 | 2 | 4 | 63.11 | 7.85 | 61.79 | 7.72 |
| Idaho | 6,748 | + 2,593 | 32 | 27 | 17.17 | 16.25 | 16.98 | 16.22 |
| Lemhi | 24,045 | − 1,515 | 37 | 31 | 24.00 | 42.77 | 6.61 | 8.39 |
| Nez Perce | .... | − 1 | 1 | .... | 15.00 | .... | 15.00 | .... |
| Owyhee | 556 | − 176 | 14 | 17 | 94.82 | 37.82 | 94.82 | 37.82 |
| Shoshone | 2,516,325 | +260,850 | 43 | 56 | 13.35 | 17.65 | 2.53 | 3.06 |
| | 2,718,045 | +309,199 | 226 | 256 | 13.59 | 17.78 | 2.72 | 3.22 |

[a] Value per ton, placer product excluded.

Classifying the deep mines according to metals produced in 1916 shows that there were 8 mines producing gold only; 75 gold and silver; 31 gold, silver, and copper; 44 gold, silver, copper, and lead; 8 gold, silver, copper, lead, and zinc; 16 gold, silver, and lead; 8 gold, silver, lead, and zinc; 1 silver alone; 3 copper alone; 26 silver and lead; 8 silver, lead, and zinc; 13 silver, copper, and lead; 8 silver and copper; 5 zinc; and 2 lead and zinc.

## REVIEW BY COUNTIES.

### ADA COUNTY.

The region near Boise, including the Black Hornet and Highland districts, produced $2,659 in gold and 30 ounces of silver at 3 placer properties. The Monitor placer on Boise River, worked by hydraulic, was the largest producer. There was no production from deep mines.

### ADAMS COUNTY.

Six deep mines produced 876 tons of ore, $3,131 in gold, 2,304 ounces of silver, and 132,637 pounds of copper, having a total value of $37,276. The ore had a total value per ton of $42.55, and consisted of 368 tons of copper ore shipped and 508 tons of siliceous ore cyanided.

*Seven Devils district.*—The entire county output came from this district, near Landore. The Idaho Gold Coin Co. operated a 50-ton cyanide plant for a short period in 1916. Copper ore was shipped from the Peacock, Blue Jacket, River Queen, Arkansas, and National Copper properties. There was decrease in the gold output, but increase in both silver and copper.

### BANNOCK COUNTY.

In the Fort Hall district a shipment of oxidized copper ore came from the Moonlight group. The Fort Hall group, operated by the Montana Development Co., also produced a small quantity of ore. In the Portneuf district a shipment of lead ore came from the Lead Bell group.

### BEAR LAKE COUNTY.

There were small shipments of copper ore and lead ore during the year. The Copper Reserve Co. operated the Hummingbird mine at Paris and made two shipments of copper ore.

### BENEWAH COUNTY.

In the Camas Cove district, the Cedar Creek property produced considerable placer gold by hydraulicking.

### BINGHAM COUNTY.

The Snake River district in Bingham County supplied only a few ounces of placer gold. A bulletin[1] on the placer operations along Snake River in various counties was published in 1915.

[1] Hill, J. M., Notes on the fine gold of Snake River, Idaho: U. S. Geol. Survey Bull. 620, pp. 271-294, 1915.

## BLAINE COUNTY.

*Mine production in Blaine County, Idaho, in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 35 | 10,560 | $27,865 | 82,466 | 2,971 | 998,063 | 441,736 | $171,879 |
| 1916 | 44 | 9,113 | 18,582 | 70,283 | 42,517 | 875,196 | 248,379 | 168,958 |
| Increase or decrease, 1916 | | −1,447 | −9,283 | −12,183 | +39,546 | −122,867 | −193,357 | −2,921 |
| Total, 1880–1916 | | | 2,455,403 | 15,418,107 | 190,385 | 179,866,831 | 4,389,632 | 24,399,938 |

Forty-four deep mines produced 9,113 tons of ore, a decrease of 1,447 tons from 1915. The ore had a total value per ton of $18.54 and a gold and silver value of $7.11. The output was divided into 6,055 tons of lead ore, 1,418 tons of siliceous ore, 1,208 tons of lead-zinc ore, 323 tons of zinc ore, and 109 tons of copper ore. In gold and silver mills 1,321 tons were treated, concentration mills took 3,757 tons, and crude ore shipped to smelters amounted to 1,143 tons. There was also 2,892 tons of old slag shipped. The crude ore shipped had a value of $72,558, or $63.48 per ton, and the concentrates, amounting to 538 tons, had a value of $53,836, or $100.06 per ton. From 1880 to 1916 this county has produced $2,455,403 in gold, $13,949,587 in silver, $32,747 in copper, $7,665,232 in lead, and $296,969 in zinc, a total of $24,399,938. The output for the county by years was published in this report[1] for 1914. The history, geology, and early production of the Antelope, Dome, Era, Lava Creek, and Muldoon districts of this county, were given in a report[2] on the Mackay region.

*Antelope district.*—A few shipments of lead ore came from the Weiler group, known as the Original Lead Belt Mining Co., near Grouse.

*Hamilton district.*—Lead ore was shipped from the Badger Creek and Frank properties, and copper ore from the Automatic mine, operated by the Copper & Uranium Mining Co.

*Lava Creek district.*—Four deep mines produced 122 tons of ore, $49 in gold, 2,310 ounces of silver, 4,330 pounds of copper, and 13,883 pounds of lead, valued in all at $3,592. The Ironsides, St. Louis, and Cut Wail properties produced lead ore, and the Horn Silver mine produced an oxidized copper ore. All the ore was shipped.

*Little Smoky district.*—The Blue Bird mine was not productive, but work was begun to change the mill to a 100-ton plant using concentration and flotation.

*Mineral Hill district.*—Twenty-one deep mines produced 800 tons of ore, $546 in gold, 10,250 ounces of silver, 1,386 pounds of copper, 125,972 pounds of lead, and 86,544 pounds of recoverable zinc, valued in all at $27,922. Eleven deep mines in 1915 produced 5,582 tons of ore valued in all at $91,329. There were 587 tons concentrated and 213 tons shipped directly to the smelters. The output was made

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 613, 1915.
[2] Umpleby, J. B., Geology and ore deposits of the Mackay region, Idaho: U. S. Geol. Survey Prof. Paper 97, 1917.

up principally of small shipments of lead ore. The Minnie Moore, formerly an important producer, was practically idle. A few hundred tons of ore were milled at the Nay Aug property, and a few shipments of zinc concentrate and lead concentrate were made.

*Skeleton Creek district.*—As in former years, gold bullion and concentrate were shipped from the El Oro property from the operations of a 10-stamp mill. Gold ore were also amalgamated from the San Mateo property.

*Warm Springs district.*—Nine deep mines produced 6,547 tons of ore, $2,337 in gold, 54,765 ounces of silver, 25,401 pounds of copper, 681,117 pounds of lead, and 161,835 pounds of recoverable zinc, valued in all at $113,303. Some of the ore (3,162 tons) was concentrated and made 432 tons of concentrates, and 493 tons were shipped directly to smelters. A large part of the production was obtained from the old Philadelphia smelter dump at Ketchum. Lead ore was shipped from the Sunday group, West Fork, and Homestake. A good grade of concentrate came from the Independence mine, and zinc ore and concentrate were shipped from the Boston-Idaho, Fetish, and North Star-Triumph. The last named property, operated by the Federal Mining & Smelting Co., of Wallace, began development in April, 1916. A large body of sulphide lead-zinc ore has since been opened at depth. The 150-ton concentration and flotation mill was started experimentally in October. Unfortunately a snowslide did considerable damage to the mine plant in December. Important shipments of both lead and zinc concentrate will be made from this property in 1917. The plant is equipped with crusher, Marcy mill, Wilfley tables, flotation cells, magnetic separator, and Dorr thickener.

## BOISE COUNTY.

*Mine production in Boise County, Idaho, in 1915 and 1916.*

| Year. | Number of producers | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 49 | 18,408 | $555,125 | 10,986 | 3,205 | 8,892 | $561,674 |
| 1916 | 49 | 18,471 | 470,060 | 23,161 | 23,260 | 92,356 | 497,395 |
| Increase or decrease, 1916 | ..... | +63 | −85,065 | +12,175 | +20,055 | +83,464 | −64,279 |

[a] Includes placer production.

Seventeen deep mines produced 18,471 tons of ore, only 63 tons more than was produced during the previous year. The total value of the ore per ton was $10.82, and the value in gold and silver was $10.16. The deep mines produced $174,889 in gold, 19,523 ounces of silver, 23,260 pounds of copper, and 92,356 pounds of lead, in all valued at $199,830. Of the ore, 112 tons were shipped directly to smelters, and 18,359 tons were treated in gold and silver mills. Bullion from these mills contained $126,144 in gold and 1,555 ounces of silver, valued at $127,167. With the exception of 94 tons of copper ore and 2 tons of copper-lead ore, the entire tonnage was siliceous. In 1916 this county was the source of nearly 66 per cent of the placer gold of the State, 32 placer mines producing $295,171 in gold and 3,638 ounces of silver, in all valued at $297,565. The

most important dredge operations in the State were carried on in this county at Idaho City.

The production of gold and silver in the county, exclusive of copper and lead, from 1863 to the end of 1916 was $51,884,853 in gold and 2,127,088 ounces of silver, or a total value of $54,142,990. The output by years was given in the report[1] for 1914.

*Banner district.*—The Banner mine, which was operated by the Boston-Idaho Gold Dredging Co., produced a shipment of rich silver ore.

*Boise Basin district.*—Fourteen deep mines and 26 placers produced 18,327 tons of ore, $467,357 in gold, 20,201 ounces of silver, 23,191 pounds of copper, and 92,273 pounds of lead, in all valued at $492,721. This was a slight decrease from a total value of $560,005 in 1915. Nearly all of the ore (18,229 tons) was treated in gold and silver mills and produced bullion containing 5,998.83 ounces of gold and 1,497 ounces of silver, as well as 993 tons of concentrates containing 2,338.21 ounces of gold, 13,518 ounces of silver, 13,032 pounds of copper, and 91,462 pounds of lead. There were 98 tons shipped directly to smelter. The district produced placer gold valued at $294,617 and 3,637 ounces of silver, both valued at $297,007. This was a decrease from the placer output of 1915, which was valued at $383,903. The Boston & Idaho Gold Dredging Co. was by far the largest placer producer, operating a big dredge near Idaho City. The production was, however, less than in former years. Other important placers of the district were the Crevasse Diggings, Richardson-Glendenning Mining Co., Native Missourian, Leary & Brogan, and Riley & Ferren properties. The most important deep mines were the Gold Hill & Iowa, National Mining & Development Co., Golden Age, and Diana mines. The Gold Hill & Iowa, at Quartzburg, operated a 100-ton amalgamation, concentration, and cyanide plant. The National operated an all-slime cyanidation plant and also shipped considerable concentrates rich in gold and silver. At the Golden Age considerable bullion was won by amalgamation, and a shipment of rich concentrates made. Extensive development work was carried on at the Enterprise and Ingle groups of the Diana Mines Co., where improvements in equipment consisted of new buildings, an Elspass mill, James concentration tables, and Callow flotation tanks. The principal products during the year were an oxidized copper ore and a lead concentrate rich in silver. The property is opened by 2,500 feet of drifts and 5,000 feet of crosscuts and adits, and most of the work was done in 1916. At the Lucky Boy mine a body of free gold ore was opened and preparations were made for milling a considerable output. A bulletin[2] on the geology and ore deposits of this district was published in 1916.

*Deadwood Basin district.*—The Merry Blue property produced gold and silver bullion in a 2-ton arrastre.

*Payette River district.*—A small amount of placer gold was won from gravel along Payette River near Cascade and Banks, Idaho.

*Summit Flat district.*—From the Black Jack property a small amount of gold bullion was secured by amalgamation.

*Unorganized or Boise River district.*—Three placer mines near Twin Springs produced $328 in gold and 4 ounces of silver.

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[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 616, 1915.

[2] Jones, E. L., jr., Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho: U. S. Geol. Survey Bull. 640, pp. 83–111, 1916.

### BONNER COUNTY.

Eight deep mines produced 1,730 tons of ore, containing $3,151 in gold, 31,119 ounces of silver, 25,317 pounds of copper, and 123,504 pounds of lead, in all valued at $38,377. This was an increase from 651 tons of ore and a total value of $17,119 in 1915. The ore had a total value per ton of $22.18 and a value in gold and silver of $13.66. The best ore, 1,276 tons, was shipped to smelters and had a total value of $30,043, or $23.62 per ton, and 454 tons were concentrated, making 73 tons of concentrates, which had a total value of $8,334, or $114.16 per ton. The ore was classified as 1,242 tons of siliceous ore, 454 tons of lead ore, 20 tons of copper-lead ore, and 14 tons of copper ore.

*Lakeview district.*—The production of three deep mines was 48 tons of ore, $104 in gold, 1,211 ounces of silver, 2,012 pounds of copper, and 10,836 pounds of lead, in all valued at $2,144. The Fall Creek property produced a copper-lead ore, and the Weber mine a shipment of silver ore.

*Pend Oreille district.*—Five deep mines produced 1,682 tons of ore, $3,047 in gold, 29,908 ounces of silver, 23,305 pounds of copper, and 112,668 pounds of lead, in all valued at $36,233, or $21.54 per ton. In 1915 five deep mines produced ore valued at $16,210. Lead ore was concentrated at the Lawrence mine and the concentrates were shipped. The most important production of the district was that of the Keystone property, near Blacktail. Shipments consisted of siliceous silver ore containing some gold. From the Venezuela property several shipments of silver ore were also made, and a shipment of copper ore came from the Green Monarch property.

### BONNEVILLE COUNTY.

*Mount Pisgah district.*—Placer gold amounting to $5,268, with 6 ounces of silver, came largely from the American Placer, near Gray. The Barnes group was also productive.

### BOUNDARY COUNTY.

*Priest Lake district.*—Considerable crude lead ore and lead concentrate were shipped from the Idaho Continental property, where the 300-ton concentration plant was rebuilt after the fire of 1915. The product, which is shipped to the International Smelting Co., at Tooele, Utah, contains about 20 ounces of silver per ton and nearly 60 per cent of lead. The mine is opened to a depth of 600 feet by three adit tunnels.

### CANYON COUNTY.

Four placers produced $1,708 in gold and 15 ounces of silver from properties along Boise River and Payette River.

### CASSIA COUNTY.

A shipment of lead ore carrying gold and silver was made from the Melcher mine in Stokes district. In the Black Pine district a shipment of zinc carbonate ore was made from the Deer Ridge property, and some zinc ore and siliceous silver ore were shipped from the Hazel Pine mine.

### CLEARWATER COUNTY.

Seventeen properties, of which one was a deep mine, produced gold valued at $26,277 and 271 ounces of silver, valued in all at $26,455. The output in 1915 was valued at $28,352.

*Burnt Creek district.*—Small placers near Dent and Elk River produced gold valued at $871 and 8 ounces of silver.

*Moose Creek district.*—A small amount of placer gold came from the eastern part of the county near Moose City.

*Pierce district.*—One deep mine and eight placers produced $25,264 in gold and 263 ounces of silver, valued in all at $25,437, a slight decrease from 1915. The main producer was the Pierce Co. (Ltd.), which operated a dredge near Pierce. A two-stamp mill was operated for a short time at the White Swan mine.

### CUSTER COUNTY.

Twenty-one deep mines produced 78,327 tons of ore, an increase of 23,523 tons. The output of the county, including the output of seven placers, was $72,539 in gold, 169,272 ounces of silver, 5,534,733 pounds of copper, and 743,842 pounds of lead, having a total value of $1,596,789. The output in 1915 was valued at $993,335. The ore was classified as 74,912 tons of copper ore, 3,414 tons of lead ore, and 1 ton of siliceous ore. Of the total output, 77,150 tons was crude ore shipped to smelters, having a total value of $1,573,564, or $20.40 per ton. Ore concentrated was 915 tons and old slag shipped 262 tons. This region was recently described in a Survey bulletin.[1]

*Alder Creek district.*—Twelve deep mines produced 77,288 tons of ore, $61,473 in gold, 158,330 ounces of silver, 5,499,342 pounds of copper, and 655,825 pounds of lead, valued in all at $1,563,744, or an average value per ton of $20.23. The output of the Copper Basin region is included in the district total. The largest copper producer in the county and State was the Empire property, at Mackay, from which both oxidized and sulphide ore were shipped to Garfield, Utah. An average of nearly 6,000 tons a month was marketed. The ore body was opened at greater depth in 1916 by a 6,000-foot adit, which is 900 feet below the old working tunnel. Dividends aggregating $170,000 were paid in 1916.

The Copper Basin mine became an important producer of copper ore containing silver and gold. About 60 cars of lead ore were shipped from the Homestake & Copper Queen property. The Horseshoe mine also made a few shipments of lead ore. There was unusual activity in the district in opening both copper and lead properties.

The Alder Creek district and other districts in the Mackay region, including parts of Custer, Fremont, and Blaine counties, were fully described in a recent publication.[2]

*Bayhorse district.*—Five deep mines produced 116 tons of ore, $16 in gold, 9,245 ounces of silver, 4,264 pounds of copper, and 79,979 pounds of lead, valued in all at $12,666, or $109.18 per ton. The output in 1915 was valued at $5,916. Small shipments of lead ore were made from the Katherine, South Butte, Forest Rose, and

[1] Umpleby, J. B., Some ore deposits of northwestern Custer County, Idaho: U. S. Geol. Survey Bull. 539, 1913.

[2] Umpleby, J. B., Geology and ore deposits of the Mackay region, Idaho: U. S. Geol. Survey Prof. Paper 97, 1917.

Excelsior. Shipments of ore rich in silver came from the old Ramshorn property.

*Loon Creek district.*—One placer and 2 deep mines produced 921 tons of ore, $6,913 in gold, 1,230 ounces of silver, 30,988 pounds of copper, and 8,038 pounds of lead, valued in all at $15,901. The Lost Packer smelter was not operated. A 50-ton flotation plant was constructed at the mine and some concentrates containing gold, silver, and copper were hauled to Mackay for shipment. The plant consists of crusher, ball mill, thickener, and flotation machines. A small shipment of lead ore came from the Sunrise group.

*Stanley Basin district.*—Four placers produced $3,552 in gold and 83 ounces of silver, valued in all at $3,606. The principal operations were on the Joe's Gulch and Sturkey groups.

*Yankee Fork district.*—A shipment of gold ore came from the Silver Queen mine, and placer gold was marketed from the Rough Creek property.

## ELMORE COUNTY.

There was a decided revival in the mines of Elmore County in 1916. Five deep mines produced 39,285 tons of ore, or 23,786 tons more than was produced in 1915. The value per ton of the ore in gold and silver, the only valuable metals contained, was $5.08, against $4.74 in 1915. The total output of the county, including that of 10 placers, was $199,003 in gold and 8,176 ounces of silver, or a total value of $204,383. The placer output was $4,934 in gold and 29 ounces of silver, a slight decrease from the previous year.

*Bear Creek district.*—Only $119 in gold and 2 ounces of silver came from one placer property and a test at a deep mine. The Elmore Placer Co. was idle during the year.

*Black Warrior district.*—At the Overlook mine a 10-stamp amalgamation mill was installed in 1916. Both the mine and the mill were operated for 35 days during the year, and some gold and silver bullion was marketed.

*Highland district.*—As in former years, a small amount of placer bullion was won by hydraulic mining from the Last Chance mine, near Twin Springs.

*Middle Boise district.*—Three deep mines and 2 placers produced 38,558 tons of ore, $189,095 in gold, and 8,038 ounces of silver, having a total value of $194,384. All of the material was milled and produced bullion by either amalgamation or cyanidation. The total represented a decided increase from the output of 1915, which was $50,434. The Atlanta Leasing Co. worked the old dumps at the Buffalo, Monarch, and Last Chance mines belonging to the Atlanta mines. The ore went through Huntington mills and over plates. Concentrates were roasted and cyanided. The most important operations were carried on at the property of the Boise Rochester Mining Co. At the 40-stamp mill, amalgamation, concentration, and cyanidation were used. A 100-ton flotation plant was added during the year. On the Jay Hawker claim a new ore body was opened, the mineral of which is partly sulphide. The ore contains some zinc, lead, antimony, and arsenic in addition to the gold and silver, which are the valuable constituents. Difficulties in mining, milling, and transportation were stated in the mining notes[1] for the year. Fif-

[1] Min. and Sci. Press, Feb. 12, 1916, p. 248.

;een miles below Atlanta, on the Middle Fork of Boise River, the Boise King Placers Co. made a small production from bench gravel.

*Snake River district.*—On Snake River 3 miles from King Hill sluicing operations resulted in fine gold from the Edna placer valued at several thousand dollars.

### FREMONT COUNTY.

Eight producing mines supplied 11,674 tons of ore, a slight increase over 1915. The product had a total value of $282,760, the total value per ton was $24.22, and the value per ton in gold and silver was $2.06. More copper ore was produced, but less lead ore.

*Dome district.*—The Daisy Black group, operated by the Wilbert Mining Co., produced sulphide lead ore treated in the 100-ton concentration mill near the mine. Lead concentrates containing some silver were shipped to a Salt Lake smelter, and dividends amounting to $40,000 were paid during the year. The fiscal report[1] of the company gives the following:

> Our main ore body has been getting continuously smaller as each new level in depth was attained and when in June, last year, the ore was reached on the No. 6 level it was of very small dimensions. In addition to this, water was encountered on the No. 6 level and also the vein had reversed its dip and was dipping very flatly to the northeast instead of to the southwest, as it had nearer the surface. To continue prospecting the ore meant a new shaft would have to be started from the No. 6 level with an inclination at about right angles to the old shaft and also that power would have to be installed for operating pumps as well as a hoist for the new shaft * * *.
>
> The shaft (which is at an inclination of only 23 degrees from the horizontal) was started down on the ore and at a depth of about 35 feet after the ore had almost pinched out, it began getting wider very rapidly, attaining in places a width of fully 8 feet. Furthermore, the grade of the ore has proven to be the best we have ever had, averaging about 40 per cent lead and 15 ounces silver, which we have sorted into two grades—the first averaging 52 per cent lead and 20 ounces silver has been shipped direct; the second class averaging approximately 20 per cent lead and 5 ounces silver has been sent to the mill for concentration before shipping. About 1,000 tons of this new ore was mined during the first four months of the present calendar year and this constituted practically all of our production for the period stated. The profit of this four months' period was $21,969.71, thus showing a net profit of over $20 per ton for this ore. * * *
>
> During the past year a total of 7,337 tons of ore was mined at a cost of $41,826.48, or $5.70 per ton. * * *
>
> A total of 1,045 feet of new work was performed in drifting and crosscutting on the various levels at a cost of $10,050.79, or $9.61 per foot. Also, the new shaft has been sunk 152 feet, which has cost, including the cutting of stations, etc., $7,492.62.
>
> During the year 6,981 tons of ore was milled, assaying 18.7 per cent lead and 4.9 ounces silver, producing 1,758 tons of concentrates assaying 54.2 per cent lead and 15.3 ounces silver, thus showing an average extraction of 72.9 per cent of the lead and 78.6 per cent of the silver. The cost of milling was $13,202.22, or $1.89 per ton.

The district, part of which is in Blaine County, is described in detail in a Survey publication[2] just issued, which also describes the mines of the Skull Canyon district and various districts of Blaine and Custer counties.

*Skull Canyon district.*—The old Weimer property, or Skull Canyon mine, near Reno, Idaho, was operated from May until December. Several carloads of ore containing approximately 15 per cent copper were shipped to a Salt Lake smelter. The ore is sulphide and contains no other metals, except a trace of silver.

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[1] Wilbert Mining Co. (Ltd.) Ann. Rept. for year ending May 15, 1917.

[2] Umpleby, J. B., Geology and ore deposits of the Mackay region, Idaho: U. S. Geol. Survey Prof. Paper 97, 1917.

*Unorganized district.*—Small shipments of lead ore were made from the Scott mine, owned by the Birch Creek Mining Co., and from various properties worked by lessees.

## GEM COUNTY.

Four deep mines and 2 placers produced 357 tons of ore, $1,590 in gold, 1,951 ounces of silver, and 190 pounds of copper, valued in all at $2,921. A few hundred tons of ore were treated by the Nellie Bloom Mining Co., near Horseshoe Bend. A small shipment of silver ore was made from the Zulu-Double Eagle group, and a sample car of gold ore came from the Virginia mines.

## GOODING COUNTY.

Four small placer operators produced $243 in gold from the banks of Snake River.

## IDAHO COUNTY.

*Mine production in Idaho County, Idaho, in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 85 | 4,155 | $97,196 | 3,262 | 1,284 | 11,401 | $99,611 |
| 1916 | 72 | 6,748 | 129,322 | 2,572 | 739 | ..... | 131,197 |
| Increase or decrease, 1916 | ..... | +2,593 | +32,126 | −690 | −545 | −11,401 | +31,586 |

[a] Includes placer production.

Twenty-seven deep mine operators produced 6,748 tons of ore, an increase of 2,593 tons, compared with 1915. The value per ton of the ore was $16.25, almost entirely from gold and silver. The total output of the county, including that of 45 placers, was valued at $131,197. The placer output was $21,373 in gold and 266 ounces of silver. All of the ore, with the exception of 23 tons of first class, was treated in gold and silver mills and produced bullion valued at $104,627, or $15.56 per ton.

*Camp Howard district.*—Placer gold, valued at $966, and 7 ounces of silver came from property near White Bird. The Cape Horn property was operated for 34 days.

*Clearwater district.*—A small gold production was reported from the Cove placers, and a shipment of gold ore was made from the Evergreen Eureka property.

*Dixie district.*—The operations of two small placers and two deep mines resulted in gold and silver valued at $384. The Olivia group near Dixie was operated four months by the owners. The property has a 10-ton Huntington mill using amalgamation and concentration.

*Elk City district.*—Ten deep mines and seven placers produced 1,433 tons of ore, $23,512 in gold and 404 ounces of silver, valued in all at $23,778. The ore was valued at $14.69 per ton. The placer output was only $2,725. The principal placer operations were at

the Golden Seal, Golden Rule, and Golden Sceptre. Ore was treated at the Black Pine, Grangeville, Hope, Last Chance, Gold Rock, and South Fork. The largest production, however, was from the Mineral Zone property, at which several hundred tons were treated by amalgamation and concentration.

*Marshall Lake district.*—The Lake Creek Placer Co., owning property 3 miles from Burgdorf, produced placer gold by hydraulic mining. The important production of the district was that from the Sherman and Corporal claims, better known as the Holte mine. The mill started operations on a good grade of gold ore on October 15, and about 2,000 tons of ore were treated by amalgamation during the remainder of the year.

*Newsome district.*—One deep mine and three placers produced gold and silver valued at $677. The Moose Creek and Mammoth were the active placers.

*Orogrande district.*—No production was reported from this region in 1916, but preparations were made for the operation of the old Crooked River property.

*Profile or Yellow Pine district.*—A small quantity of ore was treated in a 1-stamp mill on the Snowshoe property near Edwardsburg.

*Salmon River district.*—Placer gold, valued at $1,414, and 9 ounces of silver were mined at various points along Salmon River.

*Simpson district.*—Six placers produced $1,157 in gold and 6 ounces of silver, a decrease from $2,737 in gold and 16 ounces of silver in 1915. Gold was won from the Jim Crow, Spring Bar, and McGaffee claims.

*Tenmile district.*—Seven small lode mines and five placers produced 1,545 tons of ore, $24,147 in gold, and 376 ounces of silver, valued in all at $24,395. The ore had a value of $14.52 per ton, and the placer output was $1,945 in gold and 15 ounces of silver. The largest producer was the New York mine, at which a gold ore was treated by amalgamation. A considerable output also came from the Buckhorn, Equator, and Lone Pine mines. The active placers were the Alpine Bar, Crescent, Little Leggett, and Tippie.

*Thunder Mountain district.*—The output resulting from sluicing the old dumps at the Sunnyside and the Dewey mines was valued at $2,301.

*Warren district.*—Two deep mines and 12 placers produced 1,860 tons of ore, $34,304 in gold, and 677 ounces of silver, valued in all at $34,749. The ore treated had a value per ton of $15.73. The placer production was $5,458 in gold and 55 ounces of silver. An important gold production was that from the Standard property on which an amalgamation mill was operated most of the year. There were several placers which produced small amounts of gold, but the only important ones were the Gilbert or Telegram Placer, Golden Rule, Blue Bird, Rapid Creek, and Lucky Strike.

### LATAH COUNTY.

Four small placers produced $744 in gold and 2 ounces of silver. This output was principally from the Annie, Liberty, and Hard Work claims near Harvard.

## LEMHI COUNTY.

*Mine production in Lemhi County, Idaho, in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 49 | 25,560 | $182,259 | 207,436 | 179,183 | 8,791,046 | $731,965 |
| 1916 | 42 | 24,045 | 113,070 | 247,571 | 216,333 | 11,208,985 | 1,102,610 |
| Increase or decrease, 1916 | ..... | −1,515 | −69,189 | +40,135 | +37,150 | +2,417,939 | +370,645 |

[a] Includes placer production.

Thirty-one deep mines produced 24,045 tons of ore, a decrease of 1,515 tons from that produced by 37 operators in 1915. The average value of the ore, however, increased from $24 in 1915 to $42.77 in 1916 and the gold and silver value from $6.61 to $8.39. Eleven placers produced $73,957 in gold and 295 ounces of silver, or a total of $74,151. This represents a decrease from the output of 1915, which was $118,123 in gold and 449 ounces of silver. Two dredges were operated in the county in 1916. Of the total output, 2,713 tons were treated in gold and silver mills, 180 tons were concentrated, and the remainder, 21,152 tons, was shipping ore. This crude ore had a total value of $993,899, or $46.99 per ton. Concentrates, 41 tons, were valued at $18,254, or $445.21 per ton. The ore output of the county was classified as 21,018 tons of lead ore, 2,713 tons of siliceous ore, and 314 tons of copper ore. Notes on the geology of the region and estimates of the past production of the districts mentioned below were given in a report by Umpleby in 1913.[1]

*Blue Wing district.*—A test shipment of sulphide copper ore containing gold and silver was made from the Castle Rock property.

*Eldorado district.*—The principal production of the district was that of the Bohannon Dredging Co. on Bohannon Creek, 14 miles from Salmon. The season lasted 22 weeks. At the close of the year dredging was suspended and hydraulic giants were installed following difficulties on account of agricultural claims. A short article [2] on the operation of this property, the Kirtley Creek dredging ground, and of the Mullen property on Moose Creek was published in January, 1917. A test shipment of copper ore came from the Gold Point property, and a shipment of copper pyrite was made from the Harmony mine near Baker.

*Eureka district.*—Three deep mines and two placers produced 928 tons of ore, $5,994 in gold, and 49 ounces of silver, having a total value of $6,026. Several hundred tons of ore from the old Queen property were treated by amalgamation as a test of the value of the property. A few tons of ore were also treated by amalgamation at the Wickham mine. The Mullen dredge on Moose Creek, an old-style Yuba plant, made a small production. Coal for

[1] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, 1913.
[2] Hornbein, Julius, Idaho placer operations: Eng. and Min. Jour., Jan. 13, 1917, p. 95.

power is mined on the ground. The dredge was moved to better ground and a good season is expected in 1917.

*Gibbonsville district.*—A small quantity of ore was treated from the Clara Morris group, some placer gold was won from the Hughes Creek property, and a clean-up made at the mill of the American Development, Mining & Reduction Co.

*Indian Creek district.*—Several thousand dollars was won from ore treated at the Kittie Burton property by amalgamation and cyanidation. The mine and 15-stamp mill were operated intermittently by lessees.

*Junction district.*—The Junction Mines Co. was idle in 1916, but the property was sold to the Sunset Mining Co., which will make shipments in 1917.

*Kirtley Creek district.*—The most important placer production of the county was that of the Kirtley Creek Gold Dredging Co., which operated its dredge for 11 months. This modern Bucyrus plant, with buckets having a capacity of 9 cubic feet, has been active since 1911. It is possible to treat 125,000 cubic yards of gravel per month.

*Mackinaw district.*—At the Sunset property a small test was made on free gold ore by amalgamation. Placer gold was shipped from the Hockensmith placer on Arnett Creek, 7 miles from Leesburg.

*McDevitt district.*—Copper ore containing appreciable amounts of gold and a little silver was treated by concentration at the Copper Queen mine, near Tendoy. A few shipments of first-class sulphide ore were also made directly to the smelter.

*Mineral Hill district.*—Four deep mines and two placers produced 133 tons of ore, $3,842 in gold, and 86 ounces of silver, having a total value of $3,899. The ore was valued at $25.38 per ton. The principal output was that of the Merry Widow mine, which produced gold bullion and a gold concentrate. A few tons of ore were milled at the Clipper Bullion property. The placer output came from the Boulder Creek and Mint properties.

*Pratt Creek district.*—Several hundred tons of ore were treated from the Gladstone group belonging to the Climax Gold Mining & Milling Co. The plant is a 10-stamp amalgamation mill equipped with vanners. The mine was operated in a small way the entire year and the mill in August, September, and October.

*Salmon City district.*—A shipment of oxidized lead ore containing gold and silver was made from the Red Cross group.

*Spring Mountain district.*—Five deep mines produced 612 tons of ore, $500 in gold, 7,579 ounces of silver, 14,492 pounds of copper, and 331,607 pounds of lead, valued in all at $31,933, or $52.18 per ton. The output was an oxidized lead ore shipped directly to smelters, and came from the Winnie, Iron Mask, Lemhi Union, Teddy, and Silver Consolidated properties. High metal prices have made it possible to market this ore notwithstanding the long haul to Gilmore.

*Texas district.*—Eight deep mines produced 20,384 tons of ore, $18,361 in gold, 238,638 ounces of silver, 114,119 pounds of copper, and 10,870,541 pounds of lead. The total value of the output was $953,722, and the value per ton was $46.79. There was an increase in the tonnage and in all metals produced, the value of the output in 1915 having been $543,146, or $33.86 per ton. All of the ore was shipped directly to smelters, and was largely an oxidized lead ore.

The largest output, as in former years, came from the Pittsburg-Idaho mine, which produced an average of more than 1,000 tons a month for the year. Dividends amounted to $42,494. A new hoist, compressor, and electric power plant were installed. In September smelter returns were $57,867. Next in importance was the Latest Out property, from which approximately 300 tons a month were shipped. This was closely followed by the Gilmore Mining Co., which made large shipments of lead ore. Several hundred tons were shipped from the Mountain Boy mine, formerly the Oriole. Other small productions were from the Allie, Jumbo, Smuggler, and Rainbow.

### NEZ PERCE COUNTY.

Drifting on the Homestead Entry resulted in the production of a few ounces of placer gold.

### OWYHEE COUNTY.

*Mine production in Owyhee County, Idaho, in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold.[a] | Silver.[a] | Total value. |
|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | |
| 1915 | 18 | 732 | $51,206 | 36,452 | $69,687 |
| 1916 | 21 | 556 | 10,344 | 16,513 | 21,209 |
| Decrease, 1916 | | 176 | 40,862 | 19,939 | 48,478 |

[a] Includes placer production.

Seventeen deep mines in 1916 produced 556 tons of ore, a decrease of 176 tons from 1915. The total value per ton, which is that of the gold and silver value of the ore, was $37.82, against $94.82 in 1915. The value of the county output, including that of 4 placers, was $10,344 in gold and 16,513 ounces of silver, or a total value of $21,209. The output of the county, formerly large, continued to decrease. The production of gold and silver by years from 1863 to 1914 was given in the report for 1914.[1] The production of gold and silver from the discovery of gold in 1863 to and including 1916 was $21,630,858 in gold and 24,350,694 ounces of silver, having a total value of $40,387,410. With the exception of 9 tons of silver ore shipped to smelters, all of the ore output in 1916 was treated in local mills and produced bullion and a few tons of concentrates. Four placers produced $185 in gold and 5 ounces of silver.

*Carson district.*—Fourteen deep mines and 1 placer produced 460 tons of ore, $9,134 in gold, and 13,992 ounces of silver, in all valued at $18,340. The most important production came from the Nugget group, operated by the Silver City Mining & Milling Co., and the Trade Dollar group, operated by lessees. The former produced bullion containing gold and silver and shipped a few tons of silver concentrates. Some ore was taken out of the Trade Dollar, but the quantity was much less than that mined in 1915. The Trade

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 626, 1915.

Dollar and De Lamar properties, formerly notable producers, were practically idle. A few tons of ore were also treated at the Banner, Homestake, High Ore, Ontario, General Connor, and Empire properties. A test shipment of silver ore came from the Golden Sickle.

*Castle Creek district.*—The Castle Falls Mining Co. operated the Dandy Jim group and treated a small tonnage of gold and silver ore in a 5-ton cyanide plant using the all slime process.

*Steele district.*—Several ounces of placer gold came from the Meadow Creek property, near Triangle post office.

### POWER COUNTY.

Various small placer operations along Snake River, in the vicinity of Neeley and American Falls, resulted in the production of gold, valued at $1,620, and 5 ounces of silver.

### SHOSHONE COUNTY.

*Mine production in Shoshone County, Idaho, in 1915 nad 1916.*

| Year. | Number of producers | Ore. | Gold.a | Silver.a | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 52 | 2,255,475 | $46,433 | 11,158,955 | 1,941,296 | 328,398,594 | 69,685,003 | $30,119,424 |
| 1916 | 63 | 2,516,325 | 46,459 | 11,639,841 | 2,370,610 | 356,233,926 | 86,238,283 | 44,424,716 |
| Increase, 1916 | ..... | 260,850 | 26 | 480,886 | 429,314 | 27,835,332 | 16,553,280 | 14,305,292 |

a Includes placer production.

This county is usually referred to as the Coeur d'Alene region, which is the most important mining center of the State. It comprises several mining districts, the production of each of which is given separately. Fifty-six deep mines in the county produced 2,516,325 tons of ore, an increase of 260,850 tons over the output of 1915, when 43 deep mines were productive. The total value per ton of the ore as mined was $17.65 and the value per ton in gold and silver was $3.06, which correspond to $13.35 and $2.53 in 1915. The value of the county output increased nearly 48 per cent and represented more than 91 per cent of the total value of the State output. There was decided increase in the production of silver, lead, and zinc, and the value of the output of the county increased $14,305,292. The output of lead ore ranked first with 1,321,035 tons, and lead-zinc followed closely with 1,135,345 tons. There was also 36,756 tons of copper ore, 22,797 tons of zinc ore, and 392 tons of siliceous ore. Ninety-four per cent of the total ore (2,361,751 tons), and 7,273 tons of old tailings were concentrated and reduced to 379,965 tons of concentrates, containing $28,691 in gold, 8,194,986 ounces of silver, 1,662,150 pounds of copper, 267,937,682 pounds of lead, and 75,371,949 pounds of zinc, in all valued at $34,417,422, or $90.58 a ton. These concentrates were separated into 1,568 tons of copper concentrates, containing 37.22 ounces of gold, 28,549 ounces of silver, and 550,864 pounds of copper; 277,154 tons of lead concentrates, containing 1,343.37 ounces of gold, 7,745,968 ounces of silver, 1,111,286 pounds of copper, and 255,685,239 pounds of lead; 1,467

tons of zinc concentrates, containing 3.34 ounces of gold, 4,045 ounces of silver, 48,730 pounds of lead, and 1,008,327 pounds of recoverable zinc; and 99,776 tons of lead-zinc concentrates, containing 4 ounces of gold, 416,424 ounces of silver, 12,203,713 pounds of lead, and 74,363,622 pounds of recoverable zinc. In 1916 no ore was treated by amalgamation or cyanidation in the county, but there were 28 milling plants having a combined daily capacity of approximately 9,575 tons, which were active practically the entire year. Of the county total, 147,301 tons were first-class crude ore containing $15,598 in gold, 3,444,837 ounces of silver, 708,460 pounds of copper, 88,296,244 pounds of lead, and 10,866,334 pounds of recoverable zinc, in all valued at $10,005,112, or $67.92 per ton. The crude ore smelted included 392 tons of siliceous ore, containing 16.51 ounces of gold, 32,367 ounces of silver, 7,156 pounds of copper, and 12,560 pounds of lead; 972 tons of copper ore, containing 95.49 ounces of gold, 41,920 ounces of silver, and 142,717 pounds of copper; 132,137 tons of lead ore, containing 636.66 ounces of gold, 3,344,983 ounces of silver, 558,587 pounds of copper, and 87,411,607 pounds of lead; 12,492 tons of zinc ore, containing 16,360 ounces of silver, 646,916 pounds of lead, and 10,272,767 pounds of zinc; and 1,308 tons of lead-zinc ore, containing 5.91 ounces of gold, 9,207 ounces of silver, 225,161 pounds of lead, and 593,567 pounds of zinc. Seven small placer mines in the county produced $2,170 in gold and 18 ounces of silver.

Some recent accounts of the region are noted below.[1]

*Mine production in the Coeur d'Alene region, Shoshone County, Idaho, 1884–1916.*

| Year. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|
| | | *Fine ounces.* | *Pounds.* | *Tons.* | *Pounds.* | |
| 1915 | $46,433 | 11,158,955 | 1,941,296 | 164,199 | 69,685,003 | $30,119,424 |
| 1916 | 46,459 | 11,639,841 | 2,370,610 | 178,117 | 86,238,283 | 44,424,716 |
| 1884–1916 | 5,522,716 | 153,862,636 | 65,177,518 | 2,461,373 | 256,927,220 | 359,881,032 |

Since the beginning of mining in 1884 the Coeur d'Alene region has produced gold, silver, copper, lead, and zinc valued at $359,881,032—gold, $5,522,716; silver, $93,161,494; copper, $10,150,065; lead, $225,195,632; and recoverable zinc, $25,851,125. The production of this region by years, from 1884 to 1913, was given in the report for 1913.[2] From 1904 to 1916 the operators in the region mined, shipped, or treated 24,188,428 tons of ore.

*Beaver district.*—Three deep mines and 4 placers produced 146,407 tons of ore, $1,888 in gold, 253,599 ounces of silver, 2,864 pounds of copper, 12,412,092 pounds of lead, and 54,000,411 pounds of zinc, valued in all at $8,261,950, or an average value per ton for the ore of $56.42. Most of the ore (133,363 tons) was milled and made 59,756 tons of concentrates, yielding 17.76 ounces of gold, 219,204 ounces of silver, 2,864 pounds of copper, 10,658,384 pounds of lead,

[1] Easton, S. J., The Coeur d'Alene district: Eng. and Min. Jour., Jan. 6, 1917, p. 22. Bell, R. N., Mining in Idaho in 1916: Eng. and Min. Jour., Jan. 13, 1917, p. 106. Labarthe, Jules, The Bunker Hill smelter: Min. and Sci. Press, Feb. 3, 1917, p. 155.

[2] U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 780, 1914.

nd 44,176,605 pounds of recoverable zinc. The crude ore directly hipped was 13,044 tons, containing 34,380 ounces of silver, 1,753,708 ounds of lead, and 9,823,806 pounds of recoverable zinc. The lacer production was $1,521 in gold and 15 ounces of silver. There as an increase in all metals over the production of 1915, when 15,892 tons were mined, having a total value of $6,110,543. The uscumbia, operated under lease, produced several hundred tons of ad concentrate, the ore having been treated in the Idora mill, hich has crusher, rolls, Huntington mill, jigs, tables, and two anney flotation cells. Ore was also treated at this plant from the dora mine, and lead concentrate shipped to various smelters. The oncentrate assayed about 25 ounces of silver and 55 to 60 per cent ad. The important producer of the district was the Consolidated nterstate-Callahan Mining Co., the entire production of which is redited to this district, although part of the property is in Lelande istrict. The mine and mill were operated the entire year. The roducts were first-class lead ore and zinc ore, lead concentrate, nd lead-zinc concentrate. The following notes are taken from the nnual printed report[1] of the company:

Fully as much ore was placed in sight as was extracted during the last year; and is was accomplished without having to resort to further sinking, but merely by pening up extensions of the known ore bodies in levels already developed at the me we submitted to you our last annual report. We have, therefore, at this time fficient ore developed above our level No. 6 to insure operations for a period of out three to four years. A new shaft is being sunk, and within the next two onths the shaft work should be far enough advanced to permit of our establishing vel No. 7 and exploring our ore body 225 feet below the deepest workings in exist- ce at this time. This new shaft will place us in a position to supply our entire ill tonnage from levels below No. 4, when the ore bodies in the upper levels are hausted, and will enable us at the same time to carry on that amount of develop- ent work which good mining practice demands. * * *

During the fiscal year just ended we have acquired the entire group of mining aims formerly owned by the Nipsic Mining Co. This group comprises 78 acres d lies directly north of our main property. * * *

The company has also acquired a substantial interest in the Blue Grouse Mining ., which owns the Correction, Protection, Blue Grouse, and Mountain Grouse aims. * * *

The following development work has been done during the 12 months: Shaft aking, 570 feet; crosscuts, 3,229 feet; drifts, 2,073 feet; raises, 211 feet; assessment nnels, 380 feet; total, 6,463 feet; and stations and skip chutes, 41,999 cubic feet.

At a point 300 feet northwest of the Callahan Raise and 5,250 feet from the portal No. 4 tunnel a standard three-compartment shaft is being sunk to be the main rking shaft of the mine. * * *

The concentrator was remodeled and enlarged, which has greatly increased its pacity and has enabled us to make a much higher recovery. The mill was in eration 351 days during the 12 months and the average daily output, together with e sorting plant, was 187.2 tons per day. * * *

The general drawings for a new mill are finished and the first prints should be in ur hands by July 20. The foundation plans and details will be far enough along August 1 so that orders for equipment could be placed and work on construction uld be started by August 15.

The concentrate tramway was put in operation early in November, and has worked isfactorily ever since.

A summary of the quarterly reports gives the following produc- on for the calendar year 1916: There were 146,517 tons mined, which 125,960 tons were milled. Crude ore and concentrates ipped—71,848 tons—contained 4,840,356 pounds of lead in lead e and concentrates and 64,521,162 pounds of gross zinc in zinc

[1] Consolidated Interstate-Callahan Mining Co. Fourth Ann. Rept., for year ending June 30, 1916.

ore and concentrates. The total silver in the material shipped is not stated. The zinc shipments also contain some lead and silver. According to the statement filed with the assessor for Shoshone County, the shipments had a gross value of $3,983,522. Cost of extraction was $777,156; freight and treatment, $694,893; betterment and repairs, $29,936; and net profit, $2,481,537. Dividends paid during the year amounted to $2,789,940, and to date to $5,347,385.

At the Ray Jefferson property, which adjoins the Interstate Callahan on the west, a 400-ton concentration mill with flotation equipment was completed at the end of the year. Some ore was run through the mill, but no concentrates were shipped. The product was stored awaiting the completion of the Beaver branch of the Oregon-Washington Railroad & Navigation Co.

*Eagle district.*—A small placer production came from the Mother Lode and Boulder placers and from the Dunlap & Smith property. A few shipments of sulphide lead ore were made from the Jack Waite property near Union. Shipments from this property were greatly increased early in 1917.

*Evolution district.*—Six deep mines produced 715 tons of ore, $229 in gold, 42,647 ounces of silver, 13,797 pounds of copper, and 96,631 pounds of lead, valued in all at $38,353, or $53.64 per ton. As in previous years most of this production came from the Yankee Boy mine, operated by the Big Creek Leasing Co. About half of the ore comes under the classification of siliceous silver ore and contains less than 4.5 per cent lead. The remainder is a low-grade lead sulphide ore containing considerable silver. Silver ranges from 40 ounces to 285 ounces per ton and lead from 0.5 per cent to nearly 13 per cent. Some copper ore from the Nellie group was concentrated at the new 100-ton flotation mill owned by the Silverado Mining Co. A shipment of gray copper containing silver was also made from the Polaris mine. Shipments of lead ore were made from the Chester, H. E. M. group, and Charles Dickens properties.

*Hunter district.*—Seven deep mines produced 596,782 tons of ore, $9,634 in gold, 1,824,354 ounces of silver, 458,949 pounds of copper, 64,583,596 pounds of lead, and 7,570,137 pounds of recoverable zinc, valued at $6,793,627, or $11.38 per ton. This represents a large increase over the output of 1915, when 388,382 tons of ore were mined, which had a total value of $3,488,873. Nearly all of the ore (538,886 tons) and 250 tons of old tailings was concentrated and resulted in 54,111 tons of concentrates, which contained 185 ounces of gold, 1,236,232 ounces of silver, 398,277 pounds of copper, 38,777,301 pounds of lead, and 7,570,137 pounds of zinc. The crude ore shipped directly to smelters was 57,646 tons, containing 281.05 ounces of gold, 588,122 ounces of silver, 60,672 pounds of copper, and 25,806,295 pounds of lead. The important part of this production came from the Morning mine. The Gold Hunter produced lead ore and the National Copper copper ore. A few shipments of lead ore were made from the Alice mine, and lead-zinc products came from creek tailing and slimes concentrated. The Carney property and the Reindeer Queen produced small shipments of copper ore. The Morning mine of the Federal Mining & Smelting Co. was operated the entire year and shipped lead ore, lead concentrate, and lead-zinc concentrate. Development at depth has proved

his property the most valuable asset of the Federal Co. According o the statement to the county assessor, the mine produced 444,934 ons of ore, which had a gross value of $3,621,557. The cost of xtraction was $1,184,512; freight and treatment, $1,252,785; bet- erment and repairs, $177,469; and net profit, $1,006,791. Divi- ends for the year for this and other mines of the company were 509,409 and to date $13,086,795. Extracts from the printed nnual report[1] follow:

Stimulated by the high prices obtained for the metals every effort was made to ıcrease the output. The result is seen in the following comparison with the produc- on of 1915: Total shipments 1916, 137,390 tons; 1915, 75,449 tons.

The profitable mines of the company yielded, respectively, during 1916, the following rofits: Wardner, $103,844.45; Morning, $1,006,020.22; Mace, $169,660.56. * * *

*Frisco mine.*—The operation of this mine proved unprofitable, and we ceased reaking ore on August 9. A considerable tonnage of broken ore, which remained in ıe mine at that date, permitted us to continue the operation of the mill until Decem- ɜr 22, when all work was stopped. In the meantime the mill and other buildings ıd plant had been sold to the Tamarack-Custer Consolidated Mining Co. for the ım of $150,000. This amount was paid in 1917 and possession of the property given the Tamarack Co. The sale did not include the mineral rights, all of which were served by the Federal Co.

*Wardner mine.*—Only the high prices obtained made it possible to continue the ɔeration of the Wardner mine. The grade of the ore now produced at that mine ɔuld entail a loss under normal prices. It follows, therefore, that we cannot look r a much longer life for that property. Its earnings for 1916, as compared with earn- gs from other properties, is shown above.

*Mace mines.*—In both Green Hill-Cleveland and Federal territory, the pay ore ıs been bottomed, and all work below the 1,250 level has been abandoned. Pros- ɔcting in a block of ground above the 1,050 level, that was unexplored when mining ıs in progress in its vicinity, years ago, has discovered an ore shoot about 200 feet ng. The ore is of fair grade, but from its limited extent we are unable to obtain ough ore to run the mill to capacity. We hope, however, to be able to run two-thirds ne, and to continue to earn a fair profit from this operation for some time to come.

*Morning mine.*—Development during the year was very satisfactory. In driving ɜsterly on the 800 level we found an extension of the main ore shoot, which gives omise of producing a large additional tonnage. Production of ore from the mine owed an increase of 38 per cent over the production of 1915. The new develop- ɜnt just referred to was believed to warrant a further increase of output, and prepara- ns were made to treat 300 to 400 tons per day of the Morning ore at the Wallace ɔ. 1 mill. This mill was put in operation early in 1917. * * *

Ore reserves, January 1, 1917, at all properties, but principally the Morning mine, re 807,100 tons of milling ore and 78,580 tons of first-class ore. * * *

The average number of employees at all plants, exclusive of Wallace office, was s 1,223, at an average wage of $4.509 per shift. * * *

Effective February 1, 1916, a sliding wage scale was put into effect by all the mines the district. The scale is dependent upon the price of lead, and provides for the lowing additions to the regular wage scale:

Twenty-five cents per shift when lead is above $5 and not over $5.50 per 100 pounds; cents per shift when lead is above $5.50 and not over $6 per 100 pounds; 75 cents shift when lead is above $6 and not over $6.50 per 100 pounds; and $1 per shift en lead is above $6.50 per 100 pounds.

The advance in wages represents an increased labor cost of approximately 20.5 cent.

The production of the Morning mine for 1917 will probably be ected by a lawsuit brought against the Federal Co. by the Star ning Co., which claims payment of ore alleged to have been unlaw- ly extracted from Star ground.

At the Gold Hunter property the 400-ton concentration mill was erated the entire year, and lead concentrates containing silver were pped to Salida, Colo. The mine is opened by a 4,200-foot adit, ıich attained a depth of 1,400 feet, from which level there is a

[1] Federal Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1916.

shaft 1,200 feet deep. Flotation cells are used at the mill. According to the statement given the county assessor, the mine produced 119,490 tons of ore, which had a gross value of $815,779.

At the National property several thousand tons of low-grade copper ore were treated in the 500-ton concentration mill, which has flotation equipment. A good grade of copper concentrate containing silver and a little gold was shipped to Tacoma. The mill, however, was only operated for a short time, and further development at depth in the mine was deemed necessary.

*Lelande district.*—Nine deep mines produced 779,412 tons of ore, $15,357 in gold, 5,469,900 ounces of silver, 549,038 pounds of copper, 147,475,371 pounds of lead, and 11,842,672 pounds of recoverable zinc, valued at $15,512,333, or $19.90 per ton. Of the milling ore 720,925 tons and 1,920 tons of tailings was concentrated and made 120,090 tons of concentrate, and 56,567 tons of crude ore was shipped directly to the smelter. The Hercules Mining Co., at Burke, was the largest silver and lead producer of the State in 1916. Approximately 20,000 tons of milling ore a month was shipped to the mill at Wallace, and an average of more than 2,000 tons of crude ore was shipped monthly. The product is mainly lead sulphide crude ore and concentrate, as only a few shipments of crude zinc ore and concentrate were made. The greater part of the product was shipped to the Northport Smelting Co., at Northport, Wash., where three lead furnaces were operated. The company is not incorporated and publishes no annual report. According to the statement to the assessor, there were 87,179 tons extracted, but this actually means crude ore and concentrates shipped. The gross value of this output was $7,278,258. The cost of extraction was $1,501,129; freight and treatment, $2,634,028; betterment and repairs, $211,965; and net profit was $2,931,136. Estimated dividends were $3,000,000, but, according to a statement made in a recent lawsuit, the dividends to October 31, 1916, were only $1,432,000. Both mine and mill were idle about a month in 1916, but in the latter part of the year the mill was being crowded, and additions were made consisting of ball mills, classifiers, tables, and filter press. The mine is opened to a depth of 2,000 feet by tunnels, the longest of which is the Hummingbird tunnel 8,000 feet long. The size of the silver-lead deposit has increased at depth.

The Hecla Mining Co., during 1916, greatly augmented its shipments of lead sulphide ore and concentrates and increased the capacity of the mill to 700 tons. According to the county assessor, there were 250,559 tons extracted, which had a gross value of $3,281,135. Cost of extraction was $733,553; freight and treatment, $731,940; betterment and repairs, $134,583; and net profit, $1,681,059. Dividends paid by the company in 1916 amounted to $1,550,000, and to date, $5,305,000. The following extracts are taken from the report [1] to stockholders:

> The development work for the year is represented by advances of 6,420 feet. The 1,600-foot level is still the deepest level in the mine. * * * Development and exploratory work for the past year has been confined to higher levels on the old ore and to sections which have heretofore received little attention.

[1] Hecla Mining Co. Ann. Rept. for year ending Dec. 31, 1916: Wallace Miner, Mar. 8, 1917.

)n the east ore we are making a raise to the surface from No. 3 level. This ore emote from natural ventilation and not much can be done in the way of production il ventilation is provided. It requires a raise of approximately 1,400 feet to reach surface. One thousand feet of this raise is complete and we should reach day- it in April. * * *

What is probably the most important piece of development for the year is the covery of a vein of zinc-lead-silver ore which we have called the Ore-or-No-Go. is vein was first noticed as a stringer leaving the 600 stopes in the old body. * * * n June, to take advantage of high metal prices, we leased a mill from the Federal ing & Smelting Co. and were able to increase our output of milling ore to the ent of 300 tons daily. While we occupied this mill we increased the capacity of own mill so that we could crush an additional 300 tons. By the time our own mill s ready to take the increase, the lease on the Federal mill was cancelled by the ners.

We have made arrangements with the Marsh Mining Co. to use their mill at Black ud for concentrating the zinc-lead ores from the Ore-or-No-Go vein. This mill a capacity of 200 tons daily. * * *

)ur ore reserves are estimated at 1,296,000 tons. This estimate does not include r tonnage from the Ore-or-No-Go vein, as the work has not progressed sufficiently nake such estimate.

Ore milled was 184,209 tons; crude ore shipped, 16,321 tons; and ncentrates shipped, 24,510 tons. The shipping product produced 195,841 ounces of silver and 40,217,573 pounds of lead. The ratio concentration was 7.52 to 1.

The Greenhill-Cleveland Mining Co., which is controlled by the deral Mining & Smelting Co., made large shipments of crude lead e, lead concentrate, and lead-zinc concentrate. The mill at Wal- e was treating about 12,000 tons per month. According to the tement to the county assessor, shipments of crude ore and con- ntrate amounted to 29,465 tons, the gross value of which was ,851,743. Cost of extraction was $817,110; freight and treatment, 47,014; and net profit, $401,826. Ore reserves January 1, 1917, re 16,900 tons of milling ore and 1,300 tons of first-class ore. The ne is mentioned in the notes of the Federal Mining & Smelting Co. Hunter district.

Shipments consisting principally of lead concentrate and lead-zinc ncentrate were made from the Frisco property, operated by the deral Mining & Smelting Co. The plant, which uses wet concen- tion, flotation, and magnetic separation, was operated until cember 15, when work ceased and the mill and machinery were ld to the Tamarack & Custer Consolidated Mining Co. The mine is one of the important zinc producers of the year. The mine is so referred to under Hunter district.

In the early part of 1916 lead ore from the Marsh mine was shipped the mill in Ninemile Canyon, which was remodeled in 1915. The ine, however, was closed in the early part of June, as operations d become unprofitable. Ore extracted was 17,828 tons, which d a gross value of $139,111. Toward the end of the year, the mpany was reorganized, the mine partly unwatered, and plans rmulated for development work.

Lessees shipped a few tons of ore from the Burke mine, belonging the Federal Mining & Smelting Co., and several hundred tons of d tailings were concentrated along the creek.

*Placer Center district.*—Five deep mines produced 130,076 tons of e, $1,564 in gold, 465,993 ounces of silver, 50,109 pounds of copper, ,999.324 pounds of lead, and 9,412,382 pounds of zinc, valued in l at $2,547,727, or $19.59 per ton. Of the total ore 119,717 tons

and 5,103 tons of tailings were concentrated, resulting in 27,332 tons of concentrates. The crude ore shipped was 5,256 tons of lead ore. In 1915 four deep mines produced 202,370 tons of ore, valued at $3,249,107. The most important lead producer was the Tamarack & Custer Consolidated Mining Co. According to the statement to the county assessor, the shipping product, which was all lead ore and concentrate, was 15,964 tons, having a total value of $1,013,779. The cost of extraction, which included also the cost of freight and treatment, was $675,033, leaving a net profit of $338,746. Dividends amounted to $71,050. Shipments were made from January to August. The lease on the Rex mill and the contract with the American Smelting & Refining Co. both expired the latter part of the year. In December the Frisco mill was purchased and preparations were made to deliver ore into Canyon Creek instead of Ninemile Canyon.

At the Success property the concentration plant was operated on lead-zinc ore. During the year flotation equipment was improved and increased and fine grinding machinery was added. The plant has a capacity of 300 tons a day and includes a rotary drier, magnetic separation, and a dust-settling chamber. The product is principally a lead-zinc concentrate, but a few shipments of lead concentrate were made. According to the statement to the county assessor, there were 63,062 tons of ore extracted from the mine, which had a gross value of $702,902. The cost of extraction and freight and treatment was $471,862; betterment and repairs, $9,712; and net profit, $221,328. Dividends for the year were $330,000, and to date $1,125,000. The following notes are supplied by the company:[1]

> Development aggregated 5,508 feet. * * * Every level, from the 100 to the 1,500, is represented in the development. Much of this large amount of development proved to be in rather lean ground and failed to make returns commensurate with the expense.
>
> On the 1,400 level, however, an ore shoot was encountered which is 120 feet long, having a back of 100 feet and averaging 16 feet wide. This was regarded as the most important strike that had been made in the mine in years, both with respect to character and quantity of the ore and the geological conditions under which it was found.

After a long idleness, the Rex or 16-to-1 property was reopened in the later part of the year, and several thousand tons of ore were milled in December in a plant owned by the Rex Co., which had been leased to the Tamarack & Custer Co. for several years. The ore contains sulphides of lead and zinc. Lead concentrates were said to contain 19 ounces of silver and 45 per cent lead, and lead-zinc concentrates 12 per cent lead and 30 per cent zinc. The milling plant has a capacity of 250 tons and has jigs, tables, and flotation machines. In this district a considerable quantity of old creek tailings was concentrated into a zinc product. A shipment of sulphide copper ore was made from the property of the Idaho Nevada Exploration Co.

*St. Joe district.*—The Richmond Mining, Milling & Reduction Co., owning property near the Montana State line, made shipments of a good grade of copper ore containing gold and a small quantity of silver. This will be greatly increased as soon as the tramway is in operation from the mine to the railroad station at Adair.

*Summit district.*—Three deep mines and one placer produced 5,309 tons of ore, $113 in gold, 468 ounces of silver, 378 pounds of copper, 77,998 pounds of lead, and 480,517 pounds of zinc, valued in all at

[1] Success Mining Co. Ann. Rept. for year ending Dec. 31, 1916: Wallace Miner, May 24, 1917.

0,285, or $13.23 per ton for the ore. Most of the ore (5,202 tons) was ncentrated, and 107 tons were shipped directly to smelters. Zinc e was concentrated at the Murray Hill and Paragon properties. ude lead ore and zinc ore were shipped from the Terrible Edith. 1916 the Yukon Gold Co. acquired a lease on the Coeur d'Alene ning Co.'s dredging ground on Prichard Creek, near Murray, and e ground was prospected by drilling. A large dredge may be built 1917.

*Yreka district.*—Twenty-one deep mines produced 857,066 tons of e, $15,115 in gold, 3,582,255 ounces of silver, 1,194,535 pounds of pper, 117,536,230 pounds of lead, and 2,932,164 pounds of zinc, lued in all at $11,169,005, or $13.03 per ton for the ore. Judged by e value of the output, the district is the second largest in the State. arly all of the ore (843,474 tons) was milled, making 118,078 tons concentrates, and 13,592 tons were shipped directly to various ielters. In 1915 the district produced 996,186 tons of ore, which d a total value of $9,456,533. The Bunker Hill & Sullivan mine was e most important producer of the district, although the production silver and lead was not quite as large as that of the Hercules. cording to the county assessor's figures, there were 475,784 tons of e extracted which had a gross value of $6,253,048. Cost of extrac- n was $1,430,035; freight and treatment, $2,955,221; betterment d repairs, most of which was for the new smelter, $580,540; and net ofit, $1,310,971. Dividends for 1916 amounted to $1,716,750, d dividends to date are $18,489,750. Extracts from the annual port[1] follow:

The year has been one of intense activity and the mines have yielded an out- t and operating profits greater than that of any former year, which, with earnings m other sources, have resulted in a net available surplus for the year of $2,437,550.67. * * *

Under an agreement with the Alhambra Mining Co. we have begun work upon the ensively developed property of that company, situated to the eastward of our nes. An experimental pilot mill built there during the past summer has begun erating and is demonstrating that this rather unusual Alhambra ore can be success- ly milled. * * *

In my last report comment was made upon the unsatisfactory condition which sted with respect to the marketing of the product of our mines, from which condi- n we expect relief this summer when our smelting plant is completed. * * *

The electrochemical treatment of our ores, yielding metallic lead and silver with a h percentage of recovery, has been conducted in our experimental plant on a small le throughout the year, and our success in this undertaking is such as to justify the nstruction of a commercial working unit. Working plans for this unit are now being pared, with the idea of blending this process with the smelting plant which it may entually supersede. * * *

Development has advanced extensively on our No. 14, or bottom, level. This has posed ore of remarkable extent and grade, equaling in its purity and metallic con- nt any heretofore met with in these mines and substantially exceeding the general erage of past work. The full extent of this ore is not yet determined, but two faces now being advanced in good grade mineral. Our main working shaft is being sunk, d during the year the No. 15 level will be reached at a depth of 1,200 feet vertically low the Kellogg-mill-tunnel adit, and all conditions indicate that ore will certainly encountered at that level.

We have 3,453,146 tons of ore blocked out to date. * * *

The mine was in operation for the full period of twelve months and produced 467,012 ns of concentrating ore and 8,772 tons from exploration at a cost of $1,124,773.10. Thirty-nine hundred forty-four (3,944) feet of drifts, raises, crosscuts, and shaft rk were driven at a cost of $38,954.06 * * *

[1] Bunker Hill & Sullivan Mining & Concentrating Co. Ann. Rept. for year ending Dec. 31, 1916.

The concentrators were in operation for the full year. * * * During the year 475,784 tons of ore were concentrated, making the average work of the concentrators 1,300 tons per day, or, say, 1,336 tons per 24 hours of actual operation, at a cost of $286,069.71. * * *

The company shipped 75,963.96 tons concentrates, at a cost of $19,064. * * *

The ore milled—475,784 tons—assayed 9.73 per cent lead and 4.02 ounces of silver. From this tonnage, 55,770 tons of concentrates were produced containing 72,232,018 pounds of lead and 1,322,041 ounces of silver. The loss in tailings was 16.51 per cent of the lead and 26.38 per cent of the silver in ore milled, or a total of 18.11 per cent. The total cost per pound of lead was 5.67 ecnts, a considerable increase. From 1886 to 1916 the company has mined 7,393,856 tons of ore having a gross value of $70,662,409. Net smelter returns were $42,031,626, and operating profit $22,950,365.

The equipment of the smelter was also given in detail in this report reprinted from the Mining and Scientific Press of February 3, 1917. The main features follow:

One sampling mill, capacity 50 tons per hour; four 42-inch Standard Dwight & Lloyd sintering machines; one multiple-deck Wedge roaster; twenty-four charge bins of 3,400 cubic feet capacity; three steel-jacketed lead blast furnaces, 42 inches by 180 inches at tuyeres; complete lead and silver refineries; power plant, bag house, and Cottrell plant.

The Stewart Mining Co., formerly a large producer, made few shipments of lead concentrate. The lease on the Federal mill at Wallace expired March 31, and was not renewed. The company, however, is acquiring other mining property. According to the statement to the county assessor, ore extracted was 47,594 tons, valued at $334,674. Cost of extraction was $195,051; freight and treatment, $99,467; leaving a net profit of $40,156.

The Last Chance mine, of the Federal Co., produced considerable crude lead ore and concentrates shipped to various plants of the American Smelting & Refining Co. The mine was active throughout the year and a 500-ton concentration plant operated on mine ore as well as custom ore from other properties in the district. According to the statement to the county assessor, there were 127,556 tons of ore extracted, having a gross value of $696,029. The cost of extraction was $403,573; freight and treatment, $196,161; and net profit, $95,495. Notes of the operating company were given under Hunter district.

The Caledonia mine was active throughout the year, shipping crude lead ore and concentrate. Part of the lead ore is oxidized and there is more copper associated with the ore than with the other lead mines of the region. The company uses part of the Bunker Hill milling plant. The county assessor's statement gives 46,177 tons extracted, having a gross value of $1,769,670. Cost of extraction was $147,351; freight and treatment, $467,556; and net profit, $1,154,763. Dividends paid during the year amounted to $911,750 and to date, $1,794,481. According to a statement [1] to stockholders, shipments consisted of 17,464 tons of crude ore and concentrates, containing 1,297,193 ounces of silver, 741,225 pounds of copper, and 10,412,640 pounds of lead. The freight and treatment charge, which was such a large percentage of the cost, will be perceptibly reduced when the ore is treated at the Bunker Hill smelter.

[1] Caledonia Mining Co. Statement for year ending Dec. 31, 1916: Wallace Miner, Feb. 8, 1917.

The Ontario Mining Co. made large shipments of lead concentrate and a few shipments of crude ore. The statement to the county assessor gave 36,685 tons extracted, which had a gross value of 92,078. The cost of extraction was $126,567; freight and treatment, $103,329; and net profit, $162,182.

At the Hypotheek property a 200-ton concentration plant was operated and shipments of lead concentrate and a few tons of oxidized lead ore were made, largely to the Northport Smelting Co. The mill was constructed during the year, as development on the 1,000-foot level opened a good body of galena.

Concentrates were also shipped from the Sierra Nevada property, the ore being treated at the leased mill. The ore was obtained by working the old fillings on the upper levels, exploration work being done on the lower levels. According to the statement of the county assessor, there were 17,839 tons extracted, having a gross value of $4,180. Cost of extraction was $9,973, and the net loss was 5,793.

Several hundred tons of lead concentrate and one shipment of zinc concentrate came from ore milled from the property of the Black Hawk Mining & Development Co. According to the figures of the county assessor, the gross value was $39,385 and the net profit was $2,852.

The Crown Point mine of the Coeur d'Alene Development Co. was bonded to the Stewart Mining Co. in 1916, and several thousand tons of lead ore were milled with the ore from the Stewart property.

In 1916 the Highland Surprise mine became a regular and important producer of lead-zinc ore, which is reduced to a lead-zinc concentrate and a lead concentrate. Nearly 4,000 tons of this product was shipped, partly to the Anaconda zinc plant, but principally to eastern zinc smelters. The mill was enlarged and flotation cells were added. A large body of ore containing about 14 per cent zinc, 8 per cent lead, and 5 ounces of silver was opened at a depth of 440 feet.

Small shipments of lead ore or concentrate were made during the year from the Kellogg United, Wyoming, Nabob, Page, and Roanoke properties. Copper ore was milled and concentrates were shipped from the Horst-Powell property, north of Kellogg, and siliceous silver ore was shipped by the Big Creek Mining Co.

In the Pine Creek section lead-zinc ore was shipped from the Constitution, Little Pittsburg, and Douglas properties. There was considerable activity in this region, and much discussion as to the need of a railroad to prevent expensive wagon hauling. A 150-ton mill was built at the Constitution mine, at which a large body of ore is developed to a depth of 600 feet. A body of lead-zinc ore was also opened on the Denver claim in the same region. The Douglas was leased and operated by the Anaconda Copper Co. The ore containing lead and zinc is concentrated and leached at Great Falls, Mont. In December the Anaconda Co. was buying zinc ore on the following basis: It paid for 80 per cent of the gold and silver content at market price, 70 per cent of the copper at 6 cents less than market price, and 100 per cent of the zinc at 1½ cents per pound. The treatment charge is $1.50 per ton, and material containing less than 10 per cent zinc was not desired.

### TWIN FALLS COUNTY.

A few placer operators along Snake River produced $518.

## PUBLICATIONS.

A list of publications of the United States Geological Survey on metalliferous resources in Idaho was published in the report for 1914.[1]

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 639, 1915.

# GOLD, SILVER, COPPER, LEAD, AND ZINC IN WASHINGTON.

(MINES REPORT.)

By C. N. GERRY.

## PRODUCTION.

### GENERAL STATEMENT.

The value of the mine production of gold, silver, copper, lead, and zinc in Washington in 1916 was $2,048,350, nearly three times the value of the output in 1915. There was increase in all of the five metals, and particularly in the last three. A comparison of the State output by years, given in the report for 1913 [1] shows that the production of copper, lead, and zinc in 1916 was greater than during any previous year, though the gold and silver were formerly greater. Since 1860 the State has produced gold, silver, copper, lead, and zinc valued at $34,197,381, of which 79 per cent was for gold.

*Mine production of gold, silver, copper, lead, and zinc in Washington in 1915 and 1916.*

| Year. | Number of producers | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pou* | *Pounds.* | |
| 1915 | 104 | 86,677 | $391,419 | 255,837 | 1,020,926 | 295,215 | 244,906 | $744,033 |
| 1916 | 113 | 164,998 | 577,655 | 335,121 | 2,645,022 | 5,399,274 | 1,693,734 | 2,048,350 |
| Increase, 1916 | ..... | 78,321 | 186,236 | 79,284 | 1,624,096 | 5,104,059 | 1,448,828 | 1,304,317 |
| Total, 1860–1916 | ..... | ..... | 26,956,368 | 6,771,120 | 8,723,282 | 17,467,417 | 1,959,230 | 34,197,381 |

### ORE.

The quantity of ore sold or treated increased from 86,677 tons in 1915 to 164,998 tons in 1916, or more than 90 per cent. The increase was general, but especially noticeable in Ferry, Pend Oreille, Stevens, and Whatcom Counties. The total value per ton of the ore increased from $8.50 in 1915 to $12.36 in 1916, but the value per ton in gold and silver decreased from $5.93 to $4.79. Of the total output of ore nearly 43 per cent was dry or siliceous ore, more than 41 per cent copper ore, 10 per cent lead-zinc ore, and more than 5 per cent lead ore. The siliceous ore averaged per ton $9.36 in gold and silver; the copper ore, $1.83; and the lead ore, 58 cents. The siliceous ore was composed of 70,048 tons of gold ore, averaging per

[1] U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 790, 1914.

ton $7.95 in gold, 1.91 ounces of silver, and 0.83 pound of copper; and 428 tons of silver ore, averaging per ton $2.21 in gold, 49.21 ounces of silver, 5.90 pounds of copper, and 4.56 pounds of lead. The gold ore includes 10,956 tons of sulphide iron ore, containing 310.51 ounces of gold, 590 ounces of silver, and 50,205 pounds of copper. The siliceous ore, with the iron ore, averaged per ton $7.91 in gold, 2.19 ounces of silver, 0.85 pound of copper, and 0.02 pound of lead. Copper ore as mined averaged 17 cents in gold and 2.53 ounces of silver per ton and 1.89 per cent of copper, or a total value of $11.15. Lead ore averaged 0.88 ounce of silver per ton and 27.58 per cent of lead, or a total value of $38.65. Zinc ore was shipped containing 34.85 per cent of recoverable zinc, and lead-zinc ore milled and shipped averaged 1.10 per cent lead and 4.66 per cent recoverable zinc, and had a total value per ton of $14.01. All of the lead ore was shipped without treatment, as was most of the siliceous ore, but most of the lead-zinc ore and copper ore was concentrated.

*Ore and metals produced in Washington in 1916.*

| Source of production. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Placers | 23 | ..... | 400.40 | 104 | ..... | ..... | ..... |
| Dry or siliceous ore | 48 | 70,476 | 26,979.03 | 154,546 | 60,418 | 1,950 | ..... |
| Copper ore | 28 | 68,230 | 563.76 | 172,404 | 2,584,230 | 850 | ..... |
| Lead ore | 14 | 9,099 | .87 | 8,002 | 374 | 5,019,170 | ..... |
| Zinc ore | 1 | 154 | ..... | ..... | ..... | ..... | 107,338 |
| Lead-zinc ore | 2 | 17,039 | ..... | 65 | ..... | 377,304 | 1,586,396 |
| | ..... | 164,998 | 27,944.06 | 335,121 | 2,645,022 | 5,399,274 | 1,693,734 |

*Ore sold or treated from Washington in 1916, in short tons.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Zinc ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|
| Asotin | ..... | 1 | ..... | ..... | ..... | 1 |
| Chelan | 1,309 | ..... | ..... | ..... | ..... | 1,309 |
| Ferry | 45,863 | 19,033 | 22 | ..... | ..... | 64,918 |
| King | 49 | ..... | ..... | ..... | ..... | 49 |
| Kittitas | 5 | ..... | ..... | ..... | ..... | 5 |
| Okanogan | 1,627 | 339 | ..... | ..... | ..... | 1,966 |
| Pend Oreille | ..... | ..... | 8 | 154 | 14,983 | 15,145 |
| Pierce | ..... | 134 | ..... | ..... | ..... | 134 |
| Skamania | ..... | 8 | ..... | ..... | ..... | 8 |
| Snohomish | ..... | 2,098 | ..... | ..... | ..... | 2,098 |
| Stevens | 11,073 | 46,617 | 9,069 | ..... | 2,056 | 68,815 |
| Whatcom | 10,550 | ..... | ..... | ..... | ..... | 10,550 |
| | [a] 70,476 | 68,230 | 9,099 | 154 | 17,039 | 164,998 |
| Average value per ton in gold and silver | $9.36 | $1.83 | $0.58 | ..... | ..... | $4.79 |

[a] Includes 70,048 tons of gold ore and 428 tons of silver ore.

Eight milling plants were active in 1916, of which 5 used amalgamation, 1 was equipped for cyanidation, and 2 used concentration. The United Copper mill at Chewelah used flotation as well as table concentration, and a considerable quantity of ore was amalgamated at the Boundary Red Mountain property, in Whatcom County. At the Great Excelsior gold mine a 300-ton flotation mill was erected.

Gold and silver mills treated about 8 per cent of the total quantity of ore and tailings, or 12,702 tons in 1916, against 2,732 tons in 1915. Mills at Republic were idle, and most of the ore treated came from Whatcom County, near Sumas. Only 2,380 pounds of sodium cyanide was consumed, and 317 pounds of mercury. The average consumption of mercury was 0.027 pound per ton of ore amalgamated and 0.043 pound per ounce of gold and silver bullion saved. The cyanide consumption was 1.97 pounds per ton of ore and tailing treated, and 3.12 pounds per ounce of gold and silver bullion saved.

*Gold and silver produced at mills in Washington in 1916.*

| County. | Ore. | Bullion recovered from ore by— | | | | Total value. |
|---|---|---|---|---|---|---|
| | | Amalgamation. | | Cyanidation. | | |
| | | Gold. | Silver. | Gold. | Silver. | |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | |
| Chelan | [a] 284 | 166.73 | 45 | [b] 220.48 | [b] 125 | $8,116 |
| Ferry | 160 | ..... | ..... | 80.00 | 337 | 1,876 |
| Kittitas | 5 | 5.37 | 2 | ..... | ..... | 112 |
| Okanogan | 695 | 210.81 | 104 | ..... | ..... | 4,426 |
| Stevens | 8 | 6.25 | 2 | ..... | ..... | 130 |
| Whatcom | 10,550 | 6,443.55 | 400 | ..... | ..... | 133,463 |
| | 11,702 | 6,832.71 | 553 | 300.48 | 462 | 148,123 |

[a] Also yielded 2 tons of concentrates. [b] Includes bullion from 1,000 tons of old tailings.

Nearly 33 per cent of the ore output, or 53,635 tons, was concentrated, an increase from 35,210 tons in 1915. Concentrates increased from 2,584 tons to 4,130 tons. The greater part was a copper concentrate from Chewelah district of Stevens County, and most of the remainder was zinc and lead concentrates from Metaline district in Pend Oreille County. Copper concentrates averaged 21 cents in gold and 28.71 ounces of silver per ton and 10.41 per cent of copper and had an average value per ton of $70.32. Lead concentrates averaged 2.41 ounces of silver per ton and 49.19 per cent of lead and had a value per ton of $69.48. Zinc concentrates averaged 42.84 per cent of recoverable zinc and had a value per ton of $114.81.

*Mine production of metals from Washington concentrates [a] in 1916.*

| County. | Ore to concentrating mills. | Concentrates. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value of concentrates. |
|---|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Chelan | ..... | 2 | 12.00 | 5 | ..... | ..... | ..... | $251 |
| Pend Oreille | 14,983 | 907 | ..... | 65 | ..... | 26,562 | 753,984 | 102,910 |
| Stevens | 38,652 | 3,221 | 32.21 | 92,473 | 670,723 | ..... | ..... | 226,512 |
| | 53,635 | 4,130 | 44.21 | 92,543 | 670,723 | 26,562 | 753,984 | 329,673 |

[a] The concentrates from Chelan County were all gold concentrates in 1916, those from Stevens County were all classified as copper concentrates, and those from Pend Oreille were mostly zinc, except one shipment of lead concentrates.

Nearly 60 per cent of the ore, or 98,661 tons, was mined and shipped directly to smelters. Of the first-class ore, over 58 per cent was siliceous, 30 per cent copper ore, 9 per cent lead ore, 2 per cent lead-zinc ore, and less than 1 per cent zinc ore. The siliceous ore shipped to smelters averaged per ton $7.10 in gold, 2.66 ounces of silver, and 1.05 pounds of copper, and was valued at $9.10. Copper ore shipped averaged 37 cents in gold and 2.70 ounces of silver per ton and 3.23 per cent of copper and was valued at $18.07 per ton. First-class lead ore shipped had an average assay of 0.88 ounce of silver per ton and 27.58 per cent of lead and was valued at $38.65 per ton. Crude zinc ore shipped averaged 34.85 per cent recoverable zinc and had a value of $93.40 per ton. Most of the copper ore shipped, or 28,926 tons, was sulphide, containing 525.98 ounces of gold, 79,848 ounces of silver, 1,756,917 pounds of copper, and 850 pounds of lead. The sulphide lead ore shipped was 2,108 tons, containing 6,342 ounces of silver, 374 pounds of copper, and 1,955,760 pounds of lead. Of the lead-zinc ore shipped, 377 tons was sulphide, containing 159,160 pounds of lead and 160,780 pounds of recoverable zinc. The difference between these totals and the kinds of crude shipping ore given below will give the oxidized ores shipped with contents.

*Mine production of metals from Washington crude ore shipped to smelters in 1916.*

**By counties.**

| County. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| Asotin | 1 | ..... | 42 | 111 | ..... | ..... | $55 |
| Chelan | 25 | 10.00 | ..... | ..... | ..... | ..... | 207 |
| Ferry | 64,758 | 19,216.98 | 137,951 | 828,264 | 8,646 | ..... | 692,027 |
| King | 19 | 65.02 | 566 | ..... | ..... | ..... | 1,716 |
| Okanogan | 1,271 | 663.33 | 18,680 | 31,144 | 1,704 | ..... | 33,782 |
| Pend Oreille | 162 | ..... | 20 | ..... | 11,133 | 107,338 | 15,164 |
| Pierce | 134 | 1.98 | 173 | 10,381 | ..... | ..... | 2,709 |
| Skamania | 8 | ..... | 120 | 1,280 | ..... | ..... | 304 |
| Snohomish | 2,098 | 13.40 | 1,770 | 295,485 | ..... | ..... | 74,131 |
| Stevens | 30,155 | 395.56 | 82,137 | 807,634 | 5,356,229 | 832,412 | 742,024 |
| | 98,661 | 20,366.27 | 241,459 | 1,974,299 | 5,372,712 | 939,750 | 1,562,209 |

**By kinds of ore.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dry or siliceous | 57,774 | 19,833.85 | 153,526 | 60,418 | 1,950 | ..... | $526,019 |
| Copper | 29,578 | 531.53 | 79,931 | 1,913,507 | 850 | ..... | 534,364 |
| Lead | 9,099 | .80 | 8,002 | 374 | 5,019,170 | ..... | 351,699 |
| Zinc | 154 | ..... | ..... | ..... | ..... | 107,338 | 14,383 |
| Lead-zinc | 2,056 | ..... | ..... | ..... | 350,742 | 832,412 | 135,744 |

## GOLD.

The mine production of gold was valued at $577,655, against $391,419 in 1915, an increase of nearly 48 per cent. Of this total nearly 73 per cent came from ores shipped directly to smelters, about 26 per cent came from ores treated by amalgamation or cyanidation, more than 1 per cent was from placers, and less than 1 per cent was from concentrates. The table below shows that siliceous

ore supplied most of the gold or more than 96 per cent and that copper ore contained 2 per cent of the total. There was good increase in gold from siliceous ores.

*Mine production of gold in Washington in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Total. |
|---|---|---|---|---|---|
| Chelan | 10.79 | 409.20 | ..... | ..... | 419.99 |
| Clallam | 18.00 | ..... | ..... | ..... | 18.00 |
| Ferry | 22.83 | 18,860.02 | 436.15 | 0.81 | 19,319.81 |
| King | ..... | 65.02 | ..... | ..... | 65.02 |
| Kittitas | 228.38 | 5.37 | ..... | ..... | 233.75 |
| Okanogan | 44.60 | 865.53 | 8.61 | ..... | 918.74 |
| Pierce | ..... | ..... | 1.98 | ..... | 1.98 |
| Snohomish | 75.80 | ..... | 13.40 | ..... | 89.20 |
| Stevens | ..... | 330.34 | 103.62 | .06 | 434.02 |
| Whatcom | ..... | 6,443.55 | ..... | ..... | 6,443.55 |
| | 400.40 | [a]26,979.03 | 563.76 | .87 | 27,944.06 |

[a] Includes 26,932.84 ounces from gold ore and 46.19 ounces from silver ore.

## SILVER.

The mine production of silver increased from 255,837 ounces, valued at $129,709, in 1915, to 335,121 ounces, valued at $220,510, in 1916. Stevens and Ferry counties had the largest production and the largest increase. Crude ore shipped to smelters supplied 72 per cent of the total, concentrates nearly 28 per cent, and placers and mill bullion less than 1 per cent. Siliceous ore contained 46 per cent, copper ore more than 51 per cent, and lead ore more than 2 per cent.

*Mine production of silver in Washington in 1916, in fine ounces.*

| County. | Placers. | Dry or siliceous ore. | Copper ore. | Lead ore. | Lead-zinc ore. | Total. |
|---|---|---|---|---|---|---|
| Asotin | ..... | ..... | 42 | ..... | ..... | 42 |
| Chelan | 2 | 175 | ..... | ..... | ..... | 177 |
| Clallam | 3 | ..... | ..... | ..... | ..... | 3 |
| Ferry | 5 | 131,704 | 5,682 | 902 | ..... | 138,293 |
| King | ..... | 566 | ..... | ..... | ..... | 566 |
| Kittitas | 74 | 2 | ..... | ..... | ..... | 76 |
| Okanogan | 12 | 18,027 | 757 | ..... | ..... | 18,796 |
| Pend Oreille | ..... | ..... | ..... | 20 | 65 | 85 |
| Pierce | ..... | ..... | 173 | ..... | ..... | 173 |
| Skamania | ..... | ..... | 120 | ..... | ..... | 120 |
| Snohomish | 8 | ..... | 1,770 | ..... | ..... | 1,778 |
| Stevens | ..... | 3,672 | 163,860 | 7,080 | ..... | 174,612 |
| Whatcom | ..... | 400 | ..... | ..... | ..... | 400 |
| | 104 | [a] 154,546 | 172,404 | 8,002 | 65 | 335,121 |

[a] Includes 133,482 ounces from gold ore and 21,064 ounces from silver ore.

## COPPER.

The mine production of copper increased from 1,020,926 pounds, valued at $178,662, in 1915, to 2,645,022 pounds, valued at $650,675, in 1916. The production increased considerably in Stevens, Ferry, and Snohomish counties. Crude ore produced nearly 75 per cent

of the copper and concentrates more than 25 per cent. Most of the metal came from copper ore, with only a little more than 2 per cent from siliceous ore and lead ore.

*Mine production of copper in Washington in 1916, in dry pounds.*

| County. | Dry or siliceous ore. | Copper ore. | Lead ore. | Total. |
|---|---|---|---|---|
| Asotin | ..... | 111 | ..... | 111 |
| Ferry | 578 | 827,686 | ..... | 828,264 |
| Okanogan | 9,531 | 21,613 | ..... | 31,144 |
| Pierce | ..... | 10,381 | ..... | 10,381 |
| Skamania | ..... | 1,280 | ..... | 1,280 |
| Snohomish | ..... | 295,485 | ..... | 295,485 |
| Stevens | 50,309 | 1,427,674 | 374 | 1,478,357 |
| | [a] 60,418 | 2,584,230 | 374 | 2,645,022 |

[a] Includes 57,891 pounds from gold ore and 2,527 pounds from silver ore.

## LEAD.

There was a record production of lead in the State in 1916; the output increased from 295,215 pounds, valued at $13,875, in 1915 to 5,399,274 pounds, valued at $372,550, in 1916. The important production came from the Northport district of Stevens County, where a large deposit of galena and carbonate ore was opened. Less than 1 per cent of the lead came from concentrates. Of the lead ore shipped, 6,991 tons were carbonate containing 3,063,410 pounds of lead, and 2,108 tons were sulphide containing 1,955,760 pounds of lead.

## ZINC.

The mine production of recoverable zinc was 1,693,734 pounds, valued at $226,960, against 244,906 pounds, valued at $30,368, in 1915. Zinc and lead-zinc ores were mined in the Metaline and Northport districts. Crude ore supplied 939,750 pounds and concentrates 753,984 pounds.

## MINING INDUSTRY.

The condition of the mining industry in Washington in 1916 was forcefully shown in the value of the gold, silver, copper, lead, and zinc, which exceeded that of any previous year and was nearly three times that of the year 1915. There was also considerable activity in the development of manganese, antimony, and tungsten. At Chewelah there was a gradual gain in the output of copper ore, and several properties became shippers. Republic has assumed more stability since much of the property was purchased by the Northport Smelting & Refining Co. In Whatcom County, fruitful efforts have been made to develop the gold resources. Five plants supply Washington mines with smelting facilities, one at Tacoma, one at Northport, and three in British Columbia. At Northport the operation of three lead furnaces has stimulated the mines of the northeastern section. The events of the year were reviewed in several periodicals.[1]

[1] Duff, J. E., Washington mining and production: Salt Lake Min. Rev., Jan. 30, 1917; Eng. and Min. Jour., Jan. 6, 1917, p. 74.

*Mine production of gold, silver, copper, lead, and zinc in Washington in 1916.*

| County. | Ore. | Gold. | | Silver. | |
|---|---|---|---|---|---|
| | | Quantity. | Value. | Quantity. | Value. |
| | *Short tons.* | *Fine ounces.* | | *Fine ounces.* | |
| Asotin | 1 | | | 42 | $28 |
| Chelan | 1,309 | 419.99 | $8,682 | 177 | 116 |
| Clallam | | 18.00 | 372 | 3 | 2 |
| Ferry | 64,918 | 19,319.81 | 399,376 | 138,293 | 90,997 |
| King | 49 | 65.02 | 1,344 | 566 | 372 |
| Kittitas | 5 | 233.75 | 4,832 | 76 | 50 |
| Okanogan | 1,966 | 918.74 | 18,992 | 18,796 | 12,368 |
| Pend Oreille | 15,145 | | | 85 | 56 |
| Pierce | 134 | 1.98 | 41 | 173 | 114 |
| Skamania | 8 | | | 120 | 79 |
| Snohomish | 2,098 | 89.20 | 1,844 | 1,778 | 1,170 |
| Stevens | 68,815 | 434.02 | 8,972 | 174,612 | 114,895 |
| Whatcom | 10,550 | 6,443.55 | 133,200 | 400 | 263 |
| | 164,998 | 27,944.06 | 577,655 | 335,121 | 220,510 |

| County. | Copper. | | Lead. | | Recoverable zinc content. | | Total. Value. |
|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | |
| Asotin | 111 | $27 | | | | | $55 |
| Chelan | | | | | | | 8,798 |
| Clallam | | | | | | | 374 |
| Ferry | 828,264 | 203,753 | 3,646 | $252 | | | 604,378 |
| King | | | | | | | 1,716 |
| Kittitas | | | | | | | 4,882 |
| Okanogan | 31,144 | 7,661 | 1,704 | 117 | | | 39,138 |
| Pend Oreille | | | 37,695 | 2,601 | 861,322 | $115,417 | 118,074 |
| Pierce | 10,381 | 2,554 | | | | | 2,709 |
| Skamania | 1,280 | 315 | | | | | 394 |
| Snohomish | 295,485 | 72,689 | | | | | 75,703 |
| Stevens | 1,478,357 | 363,676 | 5,356,229 | 369,580 | 832,412 | 111,543 | 968,666 |
| Whatcom | | | | | | | 133,463 |
| | 2,645,022 | 650,675 | 5,399,274 | 372,550 | 1,693,734 | 226,960 | 2,048,350 |

There was general increase in the number of producers, the ore shipped and treated, and the value per ton of the ore.

*Ore sold or treated, deep mines producing, and average value of ores in Washington.*

| County. | Ore sold or treated, 1916. | | Number of deep mines producing. | | Average total value per ton.[a] | | Average value per ton in gold and silver.[a] | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Increase. or decrease. | 1915 | 1916 | 1915 | 1916 | 1915 | 1916 |
| | *Short tons.* | *Short tons.* | | | | | | |
| Asotin | 1 | + 1 | | 1 | | $55.00 | | $28.00 |
| Chelan | 1,309 | + 662 | 9 | 5 | $6.47 | 6.55 | $6.44 | 6.55 |
| Ferry | 64,918 | +19,919 | 27 | 23 | 10.22 | 10.69 | 8.99 | 7.55 |
| King | 49 | + 49 | | 1 | | 35.02 | | 35.02 |
| Kittitas | 5 | − 4 | 2 | 2 | 25.44 | 22.40 | 25.44 | 22.40 |
| Okanogan | 1,966 | + 327 | 17 | 18 | 24.31 | 19.43 | 19.05 | 15.48 |
| Pend Oreille | 15,145 | +12,034 | 1 | 1 | 9.76 | 7.80 | | |
| Pierce | 134 | + 129 | 1 | 1 | 52.20 | 20.22 | 2.40 | 1.16 |
| Skamania | 8 | + 8 | | 1 | | 49.25 | | 9.88 |
| Snohomish | 2,098 | + 1,846 | 2 | 4 | 39.30 | 35.33 | 10.67 | .60 |
| Stevens | 68,815 | +33,795 | 12 | 30 | 5.14 | 14.08 | 1.69 | 1.80 |
| Whatcom | 10,550 | + 9,555 | 2 | 3 | 12.11 | 12.65 | 12.11 | 12.65 |
| | 164,998 | +78,321 | 73 | 90 | 8.50 | 12.36 | 5.93 | 4.79 |

[a] Placer product excluded.

There were 23 active placer mines, of which 17 were worked by hydraulic and sluicing methods and 6 by drifting. Of the 90 deep mines, 34 produced gold and silver; 32, gold, silver, and copper; 13, silver and lead or gold, silver, and lead; 4, silver; 3, silver, copper, and lead; 2, gold; 1, lead and zinc; and 1, silver, lead, and zinc.

## REVIEW BY COUNTIES.

### ASOTIN COUNTY.

A small test shipment of copper ore was made from the region near Asotin, in the southeastern part of the State.

### CHELAN COUNTY.

From 5 deep mines and 2 placers, the county output was 1,309 tons of ore, $8,682 in gold, and 177 ounces of silver, in all valued at $8,798, or an increase from $4,342 in 1915. Of the total output, 284 tons of ore and 1,000 tons of old tailings were treated in gold and silver mills and yielded gold and silver valued at $8,116. Twenty-five tons of crude gold ore were shipped directly to the smelter.

*Blewett district.*—Two deep mines and 2 placers produced $3,803 in gold and 45 ounces of silver, having a total value of $3,832. The La Rica Consolidated supplied some bullion produced by amalgamation, and a small shipment of gold ore was made from the Wilder property.

*Entiat district.*—Ore and old tailings treated had a total value of $4,966. The Rex Development Co., near Wenatchee, operated a small cyanide mill principally on tailings.

### CLALLAM COUNTY.

*Ozette district.*—Placer gold valued at $372, with 3 ounces of silver, was sluiced from the beach sand near Ozette in the western part of the State.

### FERRY COUNTY.

*Mine production in Ferry County, Wash., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Total value. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | |
| 1915 | 27 | 44,999 | $351,973 | 103,472 | 317,396 | 162 | $459,985 |
| 1916 | 25 | 64,918 | 399,376 | 138,293 | 828,264 | 3,646 | 694,378 |
| Increase, 1916 | ..... | 19,919 | 47,403 | 34,821 | 510,868 | 3,484 | 234,393 |

There was marked increase in the quantity of ore mined in Ferry County in 1916, as well as the gold, silver, copper, and lead produced. There were 23 producing deep mines and 2 placer properties. The deep mines produced 64,918 tons, an increase of 19,919 tons over the output of 1915. This ore had a value per ton of $10.69 in all metals and of $7.55 in gold and silver, an increase in total value and a de-

crease in the value of gold and silver. Of the total output, 64,758 ons was shipped directly to smelters and produced a total value of 392,027, or $10.69 per ton. The remainder, 160 tons, was treated n gold and silver mills, having a total value of $1,876, or $11.73 per on. Of the total output, 45,683 tons was siliceous ore, 19,033 tons opper ore, and only 22 tons lead ore.

Ferry County produced 69 per cent of the gold of the State, 41 per ent of the silver, and 31 per cent of the copper. The geology of the egion is described in a bulletin of the United States Geological Survey.[1]

*Belcher district.*—The Belcher mine, formerly a producer of iron ore containing gold, silver, and copper, was practically idle during the year, only a small shipment being made. The Laurier mine made good shipments of copper ore containing a small amount of silver.

*Danville district.*—Four deep mines produced 18,436 tons of ore, $17,243 in gold, 2,822 ounces of silver, and 728,045 pounds of copper, having a total value of $198,199. All of the ore was shipped directly to the smelters and consisted principally of a copper sulphide ore from the Lone Star and Washington property, operated by the British Columbia Copper Co. From the Virginia mine, belonging to the Lucile Dreyfus Mining Co., shipments of siliceous gold ore were made. A shipment of copper sulphide ore came from the Delphai property.

*Enterprise district.*—A small shipment of silver ore came from the Silver Leaf property, near Covada.

*Keller district.*—A 15-ton concentration plant was erected on the Gold Cord property, and a small shipment of oxidized lead ore came from the Iron Creek property.

*Republic district.*—Fourteen deep mines produced 45,313 tons of ore, $381,627 in gold, and 130,949 ounces of silver, valued in all at $467,791, or $10.32 per ton. Most of the ore (45,153 tons) was shipped directly to smelters and contained 18,381.21 ounces of gold and 130,612 ounces of silver. The small remainder was cyanided. From 1896 to the end of 1916 the Republic district produced 422,258 tons of ore, yielding $6,116,355 in gold and 1,781,026 ounces of silver, valued together at $7,100,287. The ore, which is siliceous, continued to be in great demand by the smelters. The main property of the district was purchased by the Northport Smelting & Refining Co. for the express purpose of supplying siliceous ore to that plant. Both the North Washington cyanide mill and the San Poil plant were idle during the year, only a clean-up being made at the former. The principal producers, according to the gold content of the ore, were as follows: Surprise, Lone Pine, and Pearl mines (owned by the Northport Smelting & Refining Co. the latter part of the year), the Knob Hill, San Poil, Midget, Old Republic, Black Tail, and Ben Hur. Small shipments also came from the Morning Glory, Mountain Lion, El Caliph, and California.

The Surprise, Lone Pine, and Pearl properties were operated under a receivership the first part of the year and later by the smelting company. Shipments averaged nearly 2,000 tons per month, largely from the Lone Pine mine, where many improvements have

[1] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, 1914.

been made in development and equipment. The ore ranged from 0.37 ounce of gold and 3 ounces of silver to 1.26 ounces of gold and 8.65 ounces of silver per ton. Development continued at the Knob Hill mine, from which shipments were made at the rate of over 500 tons a month for the year. The property is in better financial condition and paid dividends early in 1917. The Tom Thumb mine, belonging to the Midget Gold Mining Co., became an important producer. The San Poil property was operated by the West Hill Mining Co. as lessee.

### KING COUNTY.

A shipment of gold ore was made from the Apex property in Miller River district, formerly an important producer.

### KITTITAS COUNTY.

*Swauk district.*—Twelve placers and two deep mines produced 5 tons of ore, $4,832 in gold, and 76 ounces of silver, both valued at $4,882. The most important placer operators at Liberty were the Becker, Fraction, Golden Rule, Old Bigney, Sunflower, and Hamilton.

### OKANOGAN COUNTY.

Eighteen deep mines and three placers produced 1,966 tons of ore, $18,992 in gold, 18,796 ounces of silver, 31,144 pounds of copper, 1,704 pounds of lead, valued in all at $39,138. This represents a slight increase in ore and in gold output, but decrease in the other metals. The value of the ore per ton decreased from $24.31 to $19.43, and the gold and silver value from $19.05 to $15.48. Most of the ore (1,271 tons) was shipped directly to smelters and 695 tons were treated in gold and silver mills. The tonnage of the county was classified as 1,627 tons of siliceous ore and 339 tons of copper ore. Suggestions[1] as to the treatment of the complex ores of the county were given by the mining department of the Washington State College at Pullman.

*Cascade or Wauconda district.*—The Toroda Development Co. operated a 40-ton amalgamation mill at the Bodie mine near Toroda. The mine is developed by a shaft 320 feet deep, 2,100 feet of drifts, and 600 feet of adits. In the same region the Phil Sheridan property, operated by the Carey Mining & Milling Co., made a small shipment of ore rich in silver.

*Conconully district.*—Several shipments of ore containing approximately 100 ounces of silver per ton were made from the Arlington property. This property was described in a recent Survey bulletin[2] on this district.

*Meyers Creek district.*—From 8 deep mines and 3 placers the output was 1,057 tons of ore yielding $14,821 in gold, 1,158 ounces of silver, and 25,916 pounds of copper, valued in all at $21,958, or $19.89 per ton. This represents an increase from 371 tons of ore and a total value of $6,341 in 1915. Only 67 tons were treated in gold and silver mills, the remainder being shipped directly to smelters. A good grade of gold ore was shipped from the Eagle property and the Reco mine

[1] Min. and Sci. Press, Jan. 8, 1916, p. 68.
[2] Jones, E. L., jr., Reconnaissance of the Conconully and Ruby mining districts, Wash.: U. S. Geol. Survey Bull. 640, pp. 11-36, 1916.

at Chesaw, and the Gold Axe property produced gold ore containing some silver and copper. The Caribou property was operated by the British Columbia Copper Co., and several shipments containing gold, silver, and copper were made to Greenwood, British Columbia. Small amounts of gold came from several placer properties, principally the Cuba Line at Molson.

*Nespelem district.*—Only a small shipment of silver ore was made from the Apache property, formerly a good producer.

*Okanogan district.*—The Spokane mine, operated by the Morgan Mines Co., near Twisp, made several shipments of silver ore containing gold and a little lead.

*Palmer Mountain district.*—A shipment of copper ore came from the Golden Chariot property, near Oroville, and another from the O. K. property.

### PEND OREILLE COUNTY.

*Metaline district.*—The Lead-Zinc Co., at Metaline, shipped both lead and zinc products, principally the latter. Ore was milled in the 125-ton concentration plant and produced zinc concentrates. Carbonate zinc ore was also shipped. This property has become the most important zinc producer in the State, as the zinc resources of the Great Western and Last Chance mines at Northport are said to be exhausted. This district was described in a bulletin[1] of the Survey in 1914.

Recent conditions in the mines and prospects were given in an article[2] in the mining press.

### PIERCE COUNTY.

*Glacier Basin district.*—The Mount Rainier Mining Co., operating at Enumclaw, made several shipments of sulphide copper ore containing gold and silver. At Tacoma, the copper smelting plant was unusually active. The new electrolytic refinery was completed in February. This and other improvements, including a new stack, were said to have cost $750,000.

### SKAMANIA COUNTY.

*Bald Mountain district.*—Small test shipments of copper ore were made from the White Swan property, operated by the Washougal Copper & Refining Co. A brief article[3] on the region was published in November, 1916.

### SNOHOMISH COUNTY.

Four deep mines and 1 placer produced 2,098 tons of ore, $1,844 in gold, 1,778 ounces of silver, and 295,485 pounds of copper. The total value of the county output was $75,703, an increase of $64,757. All of the ore was copper ore shipped directly to smelters and having a total value per ton of $35.33 and a gold and silver value of 69 cents.

*Index district.*—The Sunset property, at Index, has developed into an important copper producer during the year. The ore, which is

[1] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, p. 40, 1914.
[2] Brinsmade, R. B., Two Washington mining districts: Min. and Sci. Press, Nov. 18, 1916, p. 743.
[3] Idem, p. 744.

sulphide, contains approximately 7 per cent copper, with small amounts of gold and silver. A small shipment of copper ore was also made from the Index property.

*Monte Cristo district.*—Two small shipments of copper ore were made from the Mamie group and the Northwest property, near Silverton.

*Sultan district.*—Various small placer operators produced $1,567 in gold and 8 ounces of silver.

## STEVENS COUNTY.

*Mine production in Stevens County, Wash., in 1915 and 1916.*

| Year. | Number of producers. | Ore. | Gold. | Silver. | Copper. | Lead. | Recoverable zinc content. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | | *Short tons.* | | *Fine ounces.* | *Pounds.* | *Pounds.* | *Pounds.* | |
| 1915 | 15 | 35,020 | $4,063 | 109,750 | 617,659 | 271,915 | ..... | $180,576 |
| 1916 | 30 | 68,815 | 8,972 | 174,612 | 1,478,357 | 5,356,229 | 832,412 | 968,666 |
| Increase, 1916 | ..... | 33,795 | 4,909 | 64,862 | 860,698 | 5,084,314 | 832,412 | 788,090 |

There was a general increase in the metal output of Stevens County in 1916, whose total value amounted to $788,090. Thirty deep mines produced 68,815 tons of ore, an increase of 33,795 tons over 1915. The value per ton increased from $5.14 to $14.08 and the value in gold and silver from $1.69 to $1.80. Of the total ore, 38,652 tons were concentrated, making 3,221 tons of concentrate; 30,155 tons were shipped directly to smelters; and 8 tons were treated in gold and silver mills. Most of the ore (46,617 tons) was copper ore; 11,073 tons, siliceous ore; 9,069 tons, lead ore; and 2,056 tons, lead-zinc ore.

*Bossburg district.*—The Bonanza mine, operated by a lessee, shipped considerable sulphide lead ore, containing a little silver. Development consists of a shaft 600 feet deep and 1,200 feet of drifts.

*Chewelah district.*—From 1901 to the end of 1916 this district has produced 140,751 tons of ore, yielding $60,822 in gold, 802,542 ounces of silver, 4,603,829 pounds of copper, and 265,139 pounds of lead, having a total value of $1,377,896. Nine deep mines in 1916 produced 45,850 tons of ore, yielding $1,964 in gold, 164,716 ounces of silver, 1,231,011 pounds of copper, and 42,000 pounds of lead, valued in all at $416,074, or $9.07 per ton. Of the ore, 38,652 tons was concentrated, making 3,221 tons of concentrates valued at $226,511, or $70.32 per ton. Crude ore shipped (7,198 tons) contained 62.79 ounces of gold, 72,243 ounces of silver, 560,288 pounds of copper, and 42,000 pounds of lead, valued at $189,563, or $26.34 per ton. Formerly there was but one producer in the district, the United Copper Co. During 1916 the following mines made one or more shipments: Amazon, Blue Star, Copper King, June Echo, Krug, Liberty, Standard Chewelah, and United States. Most of the ore is copper sulphide, but the Blue Star produced lead ore and the Krug a shipment of silver ore. The United Copper mine was operated throughout the year and increased its production of both crude ore and con-

ntrate. The following notes are taken from the printed annual eport [1] of the company:

In spite of the fact that we were handicapped for electric power during the first x months, the mine has had a very successful run for the year. Since July the lectric power has been ample for our needs and we have no reason to anticipate arther trouble from this source. The plant of the Stevens County Power & Light o. is now operating with two units of thoroughly modern equipment and is well pre-ared to meet all demands for contracted power under any emergency.

During the past year we have remodeled the old mill and installed some improvements at considerable expense, but the plant is now doing very good work and making a very satisfactory saving of values. We have also built a new mill of much larger capacity than the old one, thoroughly up to date, and equipped with the most modern machinery. * * *

We are now cutting out a station on the 1,000-foot level for a large hoist, and will start work of sinking immediately for the purpose of developing ore bodies to a much greater depth. We also believe we have again located the very rich shoot of ore encountered on the 400 level, as this shoot appears on the 1,000 level running from 18 inches to 3 feet in width and extending along the vein for 250 feet. * * *

Since the last of December and up to the time of closing this report, the smelter returns have shown a steady increase in the values of both our metals; one car of concentrates carrying 60 ounces of silver to the ton and 15 per cent copper, giving net returns on this car of $4,120.61. Other shipments are showing over $100 per ton of concentrates, while the crude ore shipments are running around $40 per ton.

The mine produced 159.271 ounces of silver and 1,179,178 pounds of copper in 1916, for which the value was $372,296. Freight cost, $21,790; treatment $31,383; mining and milling, $197,542. One dividend of $10,000 was paid, and $45,218 spent in construction and equipment.

*Clugston Creek district.*—A small test shipment of lead ore was made from the Neglected group, north of Colville.

*Colville district.*—A small shipment of lead ore was made from the Oro Cache mine, and development work was continued on the Old Dominion property.

*Kettle Falls district.*—A shipment of silver ore containing some copper and lead was shipped from the Silver Queen group, belonging to the Ark Mining & Milling Co.

*Loon Lake district.*—The Loon Lake Copper Co., a new producer in 1916, made shipments of a good grade of copper ore containing a small amount of gold and silver. The ore is oxidized and averaged more than 10 per cent copper.

*Marcus district.*—A considerable quantity of iron sulphide ore was shipped from the Napoleon mine by the British Columbia Copper Co. to the smelter at Greenwood to be used as a flux. The ore contains some gold, silver, and copper.

*Northport district.*—Five deep mines produced 10,223 tons of ore containing 952 ounces of silver, 5,065,700 pounds of lead, and 832,412 pounds of recoverable zinc, in all valued at $461,702, or $45.16 per ton. The district produced only 64 tons of ore valued at $2,207 in 1915. The output in 1916 was largely the result of the discovery of lead ore in the Electric Point mine, the opening of zinc ores in the old Last Chance mine, and the continuous operation of the Northport Smelting & Refining Co.'s lead plant, which purchased the old Northport plant and blew in two new lead furnaces in March, 1916. A third furnace was completed and operated later in the year. Dwight Lloyd roasters are used, and a Cottrell precipitation plant is to be added. All of the ore of the district was shipped directly to various smelters. From the Electric Point mine, shipments of both carbonate

[1] United Copper Co. Eleventh Ann. Rept., for year ending Dec. 31, 1916.

and sulphide lead ore were made to British Columbia the last half of the year. The majority of the ore was oxidized. The property was discovered in June, 1915, began shipments in July, 1916, and 151 cars of ore were shipped in the following four months. A short article [1] on the mine appeared in December, 1916. The total shipments for the five months of 1916 were 1,194 wet tons of sulphide ore and 7,764 wet tons of carbonate. Dividends were paid early in 1917.

The Norman Mines Co. leased the Great Western and Last Chance mines and made important shipments of lead-zinc ore, both sulphide and carbonate, but principally carbonate. At the end of the year, however, the lease was given up, as no further ore was developed. Other small shipments of lead ore were made from the United Treasure, Lead Trust, and Coyote.

*Orient district.*—A small shipment of gold ore was made from the Beecher group to the Northport smelter.

*Springdale district.*—Four deep mines produced 187 tons of ore, yielding $58 in gold, 52 ounces of silver, and 34,044 pounds of copper, valued in all at $8,467. The principal producer was the Turk mine, operated by the High Grade Mining Co. The ore is hand sorted to an average of about 10 per cent copper, and the remainder is stored for treatment by flotation. Test shipments were made by the Rambler, Copper Butte, and Bonanza properties.

*Summit district.*—Several shipments of silver ore containing a little gold were made from the Daisy property, operated by the Silver Mountain Mining Co.

*Valley district.*—A few shipments of copper ore and lead ore were made from the Double Eagle mine and Admiral property, near Valley.

### WHATCOM COUNTY.

Three deep mines produced 10,550 tons of ore, yielding $133,200 in gold and 400 ounces of silver, valued together at $133,463, or $12.65 per ton. All of the ore was siliceous and was treated by the amalgamation process.

*Mount Baker district.*—The entire county output came from the Mount Baker district. The principal producer was the Boundary Red Mountain property, near Sumas. The property was equipped with a Marathon mill, and 10 stamps were added during 1916. Control of the property was secured by George Wingfield, of Reno, Nev., and the mill started operations on April 1. At the Boundary Gold Co., operating the Lone Jacket property, a 10-foot Lane mill was completed in time for a small trial run before the snow fell. At the Great Excelsior property a 300-ton flotation plant was erected the latter part of 1916.

### PUBLICATIONS.

A list of the publications of the United States Geological Survey on the metalliferous resources in Washington was given in the report for 1914.[2]

[1] Lakes, Arthur, The Electric-Point mine in Washington: Min. and Eng. World, Dec. 9, 1916, p. 991.
[2] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 654, 1915.

# TIN.

By ADOLPH KNOPF.

## GENERAL STATEMENT.

The production of metallic tin of domestic origin in 1916 was approximately 140 short tons. As in recent years, this output was derived almost wholly from Alaska. The main part of the Alaskan output was won by dredges operating in the York district, in the western part of Seward Peninsula, and the remainder was recovered incidentally to gold placer mining in the Hot Springs district, in the sector between Yukon and Tanana rivers. The bulk of the concentrate was shipped to Singapore to be smelted, but a part was sent to the recently completed tin-smelting plant at Perth Amboy, N. J.

The total importation of tin in 1916 was 74,619 short tons, Tin recovered from drosses and waste metals amounted to 17,400 tons.[1] The total supply of primary and secondary tin in the United States, exclusive of a small quantity reduced from Alaskan concentrate, therefore amounted in 1916 to 92,019 tons.

## DOMESTIC PRODUCTION AND DEVELOPMENT.

### ALASKA.

Alaska produced 232 short tons of stream tin in 1916. On the assumption that the recovery of metal was 60 per cent, the output of metallic tin was 139 tons. The York district, 100 miles northwest of Nome, yielded 162 tons of stream tin. The bulk of the output of this district was obtained from the gravels on Buck Creek, where two dredges were operated, and the remainder came from Anikovik River, where a dredge was operating on gravels containing both gold and tin. The largest producer was the York Dredging Co., whose output was 110 tons of concentrate carrying 65.5 per cent of tin, the larger part of which was shipped to Singapore to be smelted. The rest of the Alaskan output of stream tin was a by-product of gold-placer mining on Sullivan Creek, in the Hot Springs district, in the lower part of the Tanana Valley.

The only noteworthy development work done on tin lodes was at the Lost River mine, in the York district, where 15 men were employed.

The total output of tin from Alaska from the beginning of production in 1902 aggregates 767 short tons of the metal, the bulk of which is of placer origin.

[1] Dunlop, J. P., Secondary metals in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 47–48, 1917.

## NEVADA.

Tin ore has recently been found in northern Lander County, Nev., both in lodes and in the alluvium flanking the range in which the lodes occur. The tin-bearing mineral is exclusively the peculiar variety of the oxide known as "wood tin," and in its bedrock source it occurs in narrow veinlets and low-grade stringer lodes cutting a series of rhyolite flows of middle Tertiary age. The associated minerals are specular hematite, chalcedony, lussatite, tridymite, and opal. The only tin deposits known to resemble them are veins in Durango and other Mexican States. Deposits of this type differ greatly from all other kinds of tin-bearing veins, which are invariably associated with intrusive granite and occur either in the granite itself or in the adjacent rocks surrounding the granite. The resemblance of the Nevadan to the Mexican tin veins, which have never yielded largely or steadily, creates a presumption against the value of the Nevada veins, but this resemblance, although it should warn against exaggerated hopes, should not be allowed to prevent thorough and systematic prospecting.

The known tin-bearing belt is a small fraction of the great area of 1,500 square miles or more underlain by rhyolites similar to those associated with the tin ore in northern Lander County. This rhyolitic area extends at least as far north as the Nevada-Idaho State line. Clearly it is a region that merits further attention from the prospector for both its lode and its placer possibilities, especially such parts of the region as have been but superficially examined because barren of deposits of precious metals.[1]

## OTHER STATES.

There was some activity in the Carolina tin belt and in the Black Hills of South Dakota, but not more than a few tons of concentrate was produced.

## SMELTING.

A notable event in the tin industry was the beginning of smelting of Bolivian concentrate at the American Smelting & Refining Co.'s plant at Perth Amboy, N. J. The first crude metal was produced on March 7, 1916. According to Vail,[2] smelting follows standard practice. Two reverberatory furnaces are used, each of 15 tons capacity, and among the largest tin-smelting furnaces in use. The crude metal is refined electrolytically, and the refined tin averages from 99.96 to 99.98 per cent fine, or purer than Straits tin. The bulk of the concentrate smelted at Perth Amboy comes from the Llallagua mine, Bolivia, and is shipped by way of the Chilean port of Arica. According to the company[3] the smelting plant is to be enlarged, so that by the latter part of 1917 it will be producing at the rate of 18,000 tons a year. Owing to delays, however, this expectation was not realized in 1917, the output being about 6,000 tons, but it is now believed that the plant will attain a capacity of 10,000 tons a year in 1918.

[1] Knopf, Adolph, Tin ore in northern Lander County, Nev.: U. S. Geol. Survey Bull. 640, pp. 125–138, 1917.

[2] Vail, R. H., Tin smelting at Perth Amboy, N. J.: Eng. and Min. Jour., vol. 101, pp. 927–929, 1916.

[3] American Smelting & Refining Co. Eighteenth Ann. Rept., for the calendar year ended Dec. 31, 1916, p. 9, 1917.

The National Lead Co.[1] has announced its intention to build a smelting plant.

We also purchased during the year one-half of the capital stock of Williams Harvey & Co. (Ltd.), the largest tin smelters in Europe, having two plants in England, located at Liverpool and Hayle, Cornwall. The purchase contemplated the erection of a tin-smelting plant in the United States, which will be operated in connection with the English company. An American company has been incorporated under the corporate name Williams Harvey Corporation to transact the business in the United States. The National Lead Co. expends over $10,000,000 a year in the purchase of tin which it markets in the form of solder, type metals, tin pipe, Babbitt metals, and other articles. The company has for many years smelted scrap tin and tin drosses. We have also experimented for several years with the smelting of tin ores in the belief that the tin ores of Bolivia, shipped through the Panama Canal, should logically be smelted in the United States for domestic consumption. By the arrangement above outlined we have acquired the best smelting talent in Europe and also an immediate connection with the tin-ore producers on the west coast of South America.

## IMPORTS.

The quantity of tin imported in 1916, as primary metal and in concentrate, was 74,619 short tons. Of these imports 14,075 tons entered by way of the Pacific ports. There was also imported 10,186 tons of "tin scrap," valued at $144,144, but, as the low valuation indicates, this scrap did not contain much tin.

*Tin imported into the United States, 1916.*[a]

| | Quantity (short tons). | Value. |
|---|---|---|
| Tin in bars, blocks, pigs, or grain or granulated | 69,037 | $51,803,384 |
| Tin in concentrate (9,304 tons at 60 per cent) | 5,582 | 4,036,821 |
| | 74,619 | 55,840,205 |

[a] U. S. Dept. Commerce Monthly Summary, December, 1916, p. 27, 1917. The concentrate is reported as "ore," amounting to 8,307 long tons.

The tin imported as primary metal and in concentrate, amounting to 74,619 tons, is 55 per cent of the world's production for 1916.

Imports for the years 1906–1916 are given in the following table:

*Tin imported and entered for consumption in the United States, 1906–1916.*

| Year. | Quantity (short tons). | Value. | Year. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| 1906 | 50,477 | $37,447,315 | 1912 | 58,016 | $50,372,478 |
| 1907 | 41,257 | 32,074,263 | 1913 | 52,329 | 46,927,213 |
| 1908 | 41,267 | 23,923,560 | 1914 | 47,530 | 32,881,619 |
| 1909 | 47,662 | 27,538,546 | 1915 | 57,792 | 38,736,909 |
| 1910 | 52,528 | 33,913,255 | 1916 | 69,035 | 51,802,232 |
| 1911 | 53,527 | 43,346,394 | | | |

From the foregoing figures it will be seen that imports increased notably during 1916, the increase amounting practically to 17,000 tons. To supply the demands of the country in the immediate future the quantity of tin that should be imported if adequate shipping were available would average at least 7,000 short tons a month.

[1] National Lead Co. Ann. Rept. for the fiscal year ending Dec. 30, 1916, p. 6, 1917.

## PRICES.

*Average monthly prices, in cents per pound, of Straits tin in New York, 1911–1916.*[a]

| Month. | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| January | 41.39 | 43.24 | 50.425 | 37.74 | 34.30 | 41.88 |
| February | 42.83 | 43.46 | 48.63 | 39.93 | 37.32 | 42.63 |
| March | 40.76 | 42.86 | 46.835 | 38.08 | 48.935 | 50.42 |
| April | 42.20 | 44.02 | 49.12 | 36.10 | 47.98 | 51.75 |
| May | 43.10 | 46.12 | 49.07 | 33.30 | 38.78 | 49.15 |
| June | 46.16 | 47.77 | 44.82 | 30.65 | 40.37 | 42.18 |
| July | 42.06 | 44.75 | 40.27 | 31.75 | 37.50 | 38.46 |
| August | 43.45 | 45.87 | 41.668 | 50.595 | 34.39 | 38.54 |
| September | 39.98 | 49.18 | 42.375 | 32.79 | 33.13 | 38.705 |
| October | 42.21 | 50.11 | 40.41 | 30.395 | 33.08 | 41.16 |
| November | 43.13 | 49.90 | 39.805 | 33.50 | 39.375 | 44.17 |
| December | 44.97 | 49.90 | 37.62 | 33.60 | 38.75 | 42.665 |
| Average | 42.68 | 46.43 | 44.225 | 35.70 | 38.66 | 43.48 |

[a] Metal Statistics, 1917, p. 247.

## WORLD'S PRODUCTION.

The world's production of tin in 1916 was roundly 136,000 short tons, or slightly less than it has been in the preceding two years. The output of the various tin-producing regions is shown in the accompanying table.[1] The figures given are based in the main on official reports, except those for Banca, Billiton, and Nigeria, which are taken from Mineral Industry.[2]

*World's production of tin, 1914–1916, in short tons.*

| | 1914 | 1915 | 1916 |
|---|---|---|---|
| Federated Malay States | 54,927 | 52,378 | 49,134 |
| British Protected Malay States | [a] 4,000 | 4,600 | 4,900 |
| Bolivia | 25,039 | 24,409 | 23,506 |
| Banca | 15,650 | 15,426 | 16,294 |
| Billiton | 4,480 | 6,440 | 5,600 |
| China [b] | 9,000 | 9,000 | 9,000 |
| Siam [c] | 7,600 | 8,700 | 9,400 |
| Nigeria | 5,059 | 5,102 | 5,684 |
| Australia | 5,400 | 5,400 | 5,000 |
| Cornwall | 5,663 | 5,564 | [a] 4,200 |
| Union of South Africa | 2,200 | 2,280 | 2,100 |
| Other countries | 1,500 | 1,000 | 1,500 |
| | 140,518 | 140,279 | 136,320 |

[a] Estimate.
[b] Based on the estimate of the production of China for 1915 given by V. K. Ting (China's mineral resources: Far Eastern Rev., vol. 13, p. 569, 1917).
[c] Shipments to Straits Settlements.

The tin derived from lode mining (about 33,000 tons) comes mainly from Bolivia, Cornwall, South Africa, and Australia. About one-half of the output of Australia can be credited to lode mining. Analysis of the figures in the table shows that roughly 24 per cent of the world's tin production in 1916 came from lodes and about 76 per cent from placers. The bulk of the placer tin comes from the Federated Malay States and the Dutch islands of Banca and Billiton. The production of the Federated Malay States in the last four years was as follows:

| | Short tons. | | Short tons. |
|---|---|---|---|
| 1913 | 56,142 | 1915 | 52,378 |
| 1914 | 54,927 | 1916 | 49,134 |

[1] The writer is indebted to Miss L. M. Jones for assistance in compiling the information on which this table is based.
[2] Scott, Baliol, Tin: Mineral Industry, vol. 25, p. 700, 1917.

It thus appears that in the last four years the production not only has been diminishing, but has been diminishing at an increasing rate.[1] The placers of Banca and Billiton are approaching exhaustion. The output of Siam and of Nigeria, both also alluvial tin mining regions, has increased somewhat in recent years, but is not likely to expand greatly during the world war. It is therefore certain that the world's output of tin will not increase in the near future. At best, it is likely to remain stationary.

## PUBLICATIONS.

The following list includes the more recent publications relating to tin deposits in the United States. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Washington, D. C. Those marked "Exhausted" and the other publications can be consulted at the large public or university libraries of the country.

COLLIER, A. J., Tin ore at Spokane, Wash.: U. S. Geol. Survey Bull. 340, pp. 295–305, 1908. 30c.

The tin ore is cassiterite, which is apparently an original constituent of pegmatite. About 125 tons, containing 4 per cent of metallic tin, were extracted.

DARTON, N. H., U. S. Geol. Survey Geol. Atlas, Sundance folio (No. 127), 12 pp., 1905. Exhausted.

Gives a geologic map and structure sections of the Tinton (Nigger Hill) tin-bearing area of the northern Black Hills. The deposits are briefly described.

EAKIN, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 37–38, 1913.

Cassiterite occurs in gold placers and is recovered as a by-product of the gold placer mining.

——— Tin mining in Alaska: U. S. Geol. Survey Bull. 622, pp. 81–94, 1915.

A concise but full description of the geology of the Alaskan tin deposits, both lode and placer, and of the condition of the tin-mining industry.

FAIRBANKS, H. W., The tin deposits at Temescal, southern California: Am. Jour. Sci., 4th ser., vol. 4, pp. 39–42, 1897.

The ore forms irregular shoots in quartz-tourmaline veins inclosed in granite. The ore milled averaged 5 per cent of cassiterite.

GRATON, L. C., Reconnaissance of some gold and tin deposits in the southern Appalachians: U. S. Geol. Survey Bull. 293, 134 pp., 1906. 15c.

The tin ore of the Carolinas occurs as an original constituent of pegmatite dikes. Detailed descriptions of the deposits are given.

HESS, F. L., Tin, tungsten, and tantalum deposits of South Dakota: U. S. Geol. Survey Bull. 380, pp. 131–163 (tin, pp. 134–149), 1909. 40c.

Describes the tin deposits of the Black Hills. The ore occurs in small shoots in pegmatite dikes and quartz veins.

HESS, F. L., and EVA, Bibliography of the geology and mineralogy of tin: Smithsonian Misc. Coll., vol. 58, No. 2, 408 pp., 1912.

Is an exhaustive bibliography of the geology, mineralogy, mining, milling, metallurgy, history, and statistics of tin.

HESS, F. L., and GRATON, L. C., The occurrence and distribution of tin: U. S. Geol. Survey Bull. 260, pp. 161–187, 1905. Exhausted.

Is a concise account of the geologic occurrence and distribution of tin deposits throughout the world.

JOHNSON, B. L., Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, Alaska: U. S. Geol. Survey Bull. 442, pp. 246–250, 1910. 40c.

The gold-bearing gravels average 1 to 2 pounds of concentrate (chiefly wolframite and cassiterite, with some magnetite and garnet).

[1] Shortage of Malayan tin: Min. Jour. (London), vol. 117, p. 316, 1917.

KEITH, ARTHUR, and STERRETT, D. B., Tin resources of the Kings Mountain district, North Carolina and South Carolina: U. S. Geol. Survey Bull. 660, pp. 123–146, 1917 (Bull. 660–D).

Describes the geology of the Carolina tin belt and the tin deposits, except some near Lincolnton, N. C. The development work done to date is described.

KNOPF, ADOLPH, Geology of the Seward Peninsula tin deposits: U. S. Geol. Survey Bull. 358, 72 pp., 1908.

The geology and tin deposits of the York district and of Ear Mountain, both in the western part of Seward Peninsula, Alaska, are described in detail.

——— Tin ore in northern Lander County, Nev.: U. S. Geol. Survey Bull. 640, pp. 125–138, 1916.

The recently discovered lode and alluvial tin deposits are described. The lode tin ore consists of wood tin associated with specular hematite, chalcedony, lussatite, tridymite, and opal. The veins occur in rhyolite flows of middle Tertiary age.

RICHARDSON, G. B., Tin in the Franklin Mountains, Tex.: U. S. Geol. Survey Bull. 285, pp. 146–149, 1906. Exhausted.

——— U. S. Geol. Survey Geol. Atlas, El Paso folio (No. 166), pp. 9–10, 1909. To be obtained from the Geological Survey for 5c.

Narrow quartz veins carrying cassiterite traverse post-Carboniferous granite.

SCHALLER, W. T., Cassiterite in San Diego County, Cal.: U. S. Geol. Survey Bull. 620, pp. 351–354, 1916.

A pocket of cassiterite crystals was found in a pegmatite dike.

UMPLEBY, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 74, 76, 1913.

Some wood tin has been found in the gravels of Silver and Panther creeks.

# COPPER.

By B. S. Butler.

## INTRODUCTION.

In the production of metallic copper suitable for commercial purposes at least three distinct processes are usually required, namely, mining, smelting, and refining. The Lake Superior native copper district is the only important producer where these three processes are not entirely distinct. It is possible, therefore, to ascertain the copper output of the country by collecting statistics from the mines, from the smelters, and from the refineries, and each of these sets of figures has its advantages. The mine figures have the advantage of giving the most accurate distribution of the production but are less accurate in total quantity of copper recovered; the smelter figures permit of reasonably accurate distribution and also furnish the actual recovery of copper from the ores treated during the year; the refinery figures furnish the best measures of the copper made available for commerical uses during the year, but at this stage of manufacture the accurate distribution to the State of origin, or even the separation of copper derived from domestic and from foreign sources, is uncertain.

Statistics for 1916 showing the production of each of these stages of manufacture have been collected by the United States Geological Survey, and are presented in the following report.

As the same material passes through the three processes of manufacture at successive periods, usually requiring two to three months from the time it is taken from the mine before it reaches the stage of refined copper, the year's production as recorded for the different stages does not represent the same materials—that is, the refinery production for the calendar year 1916 represents the mine production from about October 1, 1915, to October 1, 1916. The three sets of figures representing the successive stages of manufacture do not, therefore, necessarily agree, although they should not differ greatly if the condition of the industry is normal. The mine figures and the smelter figures will differ by the difference in the quantity of ore, matte, and other materials in stock at the beginning and at the end of the year and by the difference in the quantity of copper reported by the mines and that recovered by the smelters. This difference is due to the fact that considerable copper is recovered from sulphur, lead, zinc, and siliceous ores carrying values in copper so low that the mines do not receive pay for and frequently do not report the copper content of the ore, although it is eventually recovered by the smelters. The smelter and refinery figures will differ by the increase or decrease in stock of blister and other unrefined forms of copper at the beginning and at the end of the year and by the loss in refining.

As the smelter production permits reasonably accurate distribution as to the source by States and also gives the actual output of copper, it is adopted in this report as the production of the country. It is made up of the production of blister copper and of furnace-refined or ingot copper of the Lake district.

## SUMMARY OF STATISTICS.

*Summary of statistics of the copper industry in the United States in 1912, 1913, 1914, 1915, and 1916.*

| | 1912 | 1913 | 1914 |
|---|---|---|---|
| Production of copper: | | | |
| Smelter output....pounds.. | 1,243,268,720 | 1,224,484,098 | 1,150,137,192 |
| Mine production....do.... | 1,249,094,891 | 1,235,569,727 | 1,148,431,437 |
| Refinery production of new copper— | | | |
| Electrolytic....do.... | 914,935,371 | 1,022,497,601 | 991,573,073 |
| Lake....do.... | 231,112,228 | 155,715,286 | 158,009,748 |
| Casting and pig....do.... | 57,629,296 | 58,611,026 | 60,840,368 |
| Total domestic....do.... | 1,203,676,895 | 1,236,823,913 | 1,210,423,189 |
| Total domestic and foreign....do.... | 1,568,104,478 | 1,615,067,782 | 1,533,781,394 |
| Total new and old copper....do.... | 1,843,000,000 | 1,888,000,000 | 1,790,000,000 |
| Total ore produced....short tons.. | 35,671,028 | 36,361,101 | 35,187,118 |
| Copper ore produced....do.... | 35,656,414 | 36,336,683 | 35,175,541 |
| Average yield of copper....per cent.. | 1.71 | 1.67 | 1.60 |
| Average price per pound....cents.. | 16.5 | 15.5 | 13.3 |
| Imports....pounds.. | 410,240,295 | 408,778,954 | 306,350,827 |
| Exports....do.... | 775,000,658 | 926,241,092 | 840,080,922 |
| Consumption: | | | |
| Total new copper....do.... | 775,978,332 | 812,068,639 | 620,445,373 |
| Total new and old copper....do.... | 1,051,000,000 | 1,085,000,000 | 968,000,000 |
| World's production....do.... | 2,259,158,107 | 2,198,733,223 | 2,068,973,915 |
| Value of production in the United States.... | $205,139,338 | $189,795,035 | $152,968,000 |

| | 1915 | 1916 |
|---|---|---|
| Production of copper: | | |
| Smelter output....pounds.. | 1,388,009,527 | 1,927,850,548 |
| Mine production....do.... | 1,488,071,528 | 2,005,875,312 |
| Refinery production of new copper— | | |
| Electrolytic....do.... | 1,114,345,342 | 1,579,620,513 |
| Lake....do.... | 236,757,062 | 269,794,531 |
| Casting and pig....do.... | 36,003,119 | 39,337,155 |
| Total domestic....do.... | 1,387,705,523 | 1,888,752,199 |
| Total domestic and foreign....do.... | 1,634,204,448 | 2,259,387,315 |
| Total new and old copper....do.... | 2,026,000,000 | 2,922,000,000 |
| Total ore produced....short tons.. | 43,415,133 | 57,953,357 |
| Copper ore produced....do.... | 43,404,182 | 57,863,365 |
| Average yield of copper....per cent.. | 1.66 | 1.70 |
| Average price per pound....cents.. | 17.5 | 24.6 |
| Imports....pounds.. | 315,698,449 | 462,335,980 |
| Exports....do.... | 681,917,955 | 784,006,486 |
| Consumption: | | |
| Total new copper....do.... | 1,043,497,328 | 1,429,755,266 |
| Total new and old copper....do.... | 1,435,000,000 | 2,024,000,000 |
| World's production....do.... | 2,346,300,299 | 3,106,995,660 |
| Value of production in the United States.... | $242,902,000 | $474,288,000 |

*Copper produced in the United States in 1913, 1914, 1915, and 1916.*

[Smelter output, in pounds fine.]

| | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|
| Alaska | 23,423,070 | 24,985,847 | 70,695,286 | 113,823,064 |
| Arizona | 404,278,809 | 382,449,922 | 432,467,690 | 694,847,307 |
| California | 32,492,265 | 29,784,173 | 37,658,444 | 43,400,876 |
| Colorado | 9,052,104 | 7,316,066 | 7,272,178 | 9,536,193 |
| Georgia | | | | 803,609 |
| Idaho | 8,711,490 | 5,875,205 | 6,217,728 | 7,248,794 |
| Maryland | | 12,248 | 15,426 | 126,965 |
| Michigan | 155,715,286 | 158,009,748 | 238,956,410 | 269,794,531 |
| Missouri | 576,204 | 53,519 | 306,406 | 377,575 |
| Montana | 285,719,918 | 236,805,845 | 268,263,040 | 352,139,768 |
| Nevada | 85,209,536 | 60,122,904 | 67,757,322 | 100,816,724 |
| New Jersey | | | | 4,115 |
| New Mexico | 50,196,881 | 64,204,703 | 62,817,234 | 79,863,439 |
| North Carolina | 180 | 19,712 | 33,383 | 5,961 |
| Oregon | 77,812 | 5,599 | 797,471 | 2,433,567 |
| Pennsylvania | 245,337 | 422,741 | | 904 |
| Tennessee | 19,489,654 | 18,661,112 | 18,205,308 | 14,556,278 |
| Texas | 39,008 | 34,272 | 38,971 | 86,468 |
| Utah | 148,057,450 | 160,589,660 | 175,177,695 | 232,335,950 |
| Vermont | 5,771 | | 23,995 | 324,400 |
| Virginia | 46,961 | 17,753 | 50,008 | 1,066,143 |
| Washington | 732,742 | 683,602 | 903,661 | 2,473,481 |
| Wyoming | 362,235 | 17,062 | 351,871 | 1,784,351 |
| Undistributed | 51,385 | 65,479 | | |
| | 1,224,484,098 | 1,150,137,192 | 1,388,009,527 | 1,927,850,548 |

World's production of copper (smelter output) for the years 1906 to 1916, in pounds.

| Country. | 1906 a | 1907 a | 1908 a | 1909 a | 1910 a | 1911 a | 1912 a | 1913 a | 1914 b | 1915 b | 1916 b |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Germany | 45,561,600 | 45,897,600 | 45,194,300 | 50,264,880 | 55,335,460 | 49,162,580 | 56,437,760 | 55,776,380 | 67,196,208 | c 77,161,000 | c 77,161,000 |
| England | 1,120,000 | 1,568,000 | 1,543,220 | 1,543,220 | 1,102,300 | 1,102,300 | 661,380 | 661,380 | 764,996 | 524,694 | 551,150 |
| Italy | 6,417,600 | 7,392,000 | 6,613,800 | 6,172,880 | 7,275,180 | 5,731,960 | 5,070,580 | 3,527,360 | 5,313,086 | 2,072,324 | c 2,204,600 |
| Norway | 13,706,800 | 16,702,400 | 20,502,780 | 20,725,240 | 23,368,760 | 20,943,700 | 24,471,060 | 19,400,480 | c 24,250,600 | 71,451,086 | 77,161,000 |
| Austria-Hungary | 3,214,400 | 2,340,800 | 8,597,940 | 13,888,980 | 5,070,580 | 5,731,960 | 8,818,400 | 9,088,860 | 7,297,226 | | |
| Russia | 23,497,600 | 33,600,000 | 44,973,840 | 39,682,800 | 50,044,420 | 57,319,600 | 73,854,100 | 74,735,940 | 70,410,514 | c 77,161,000 | c 35,273,600 |
| Sweden | 1,120,000 | 4,480,000 | 4,409,200 | 4,409,200 | 4,409,200 | 4,409,200 | 3,306,900 | 2,204,600 | 10,343,983 | 10,055,180 | |
| Spain and Portugal | 110,476,800 | 111,272,000 | 117,725,640 | 116,843,800 | 112,655,060 | 116,843,800 | 132,055,540 | 120,591,020 | 129,220,424 | c 77,161,000 | c 110,230,000 |
| Turkey | 952,000 | 2,800,000 | 2,425,060 | 1,763,680 | 1,322,760 | 2,204,600 | 1,102,300 | 1,102,300 | | | |
| Servia | | | | | 10,802,540 | 19,400,480 | 16,314,040 | 14,109,440 | | | |
| Total Europe | 206,068,800 | 226,052,800 | 251,985,780 | 255,292,680 | 271,386,260 | 282,850,180 | 322,092,060 | 301,148,360 | 314,797,037 | 315,586,284 | 302,581,350 |
| Canada | 55,609,888 | 56,979,205 | 63,702,873 | 52,493,863 | 55,692,369 | 55,648,011 | 77,832,127 | 76,976,925 | 75,735,960 | 100,785,150 | 119,770,814 |
| Mexico | 135,800,000 | 126,705,600 | 89,506,760 | 126,103,120 | 131,614,620 | 125,000,820 | 162,479,020 | 116,402,880 | 80,108,550 | 68,274,257 | 111,625,577 |
| Cuba | | | 6,613,800 | 5,952,420 | 7,716,100 | 9,920,700 | 9,700,240 | 7,495,640 | 13,780,954 | 19,479,845 | 20,527,080 |
| Newfoundland | 5,140,800 | 3,875,200 | 3,306,900 | 3,086,440 | 2,425,060 | 2,645,520 | 1,102,300 | | | | |
| United States | 917,805,700 | 868,996,500 | 942,570,000 | 1,092,951,624 | 1,080,159,509 | 1,097,232,700 | 1,243,268,720 | 1,224,484,098 | 1,150,137,192 | 1,388,009,527 | 1,927,850,548 |
| Total North America | 1,114,356,388 | 1,056,556,505 | 1,105,700,333 | 1,280,587,467 | 1,277,607,658 | 1,290,447,751 | 1,494,382,407 | 1,425,359,543 | 1,319,762,656 | 1,576,548,779 | 2,179,773,969 |
| Argentina | 235,200 | 492,800 | 440,920 | 1,322,760 | 661,380 | 2,204,600 | 661,380 | 220,460 | | | |
| Bolivia | 5,600,000 | 5,600,000 | 5,511,500 | 4,629,660 | 5,511,500 | 3,968,280 | 8,157,020 | 8,157,020 | 6,047,217 | c 6,613,800 | c 8,818,400 |
| Chile | 57,668,800 | 59,774,400 | 85,758,940 | 80,247,440 | 78,924,680 | 66,358,460 | 83,554,340 | 88,184,000 | 90,115,229 | 114,817,772 | 157,474,578 |
| Peru | 19,051,200 | 23,688,000 | 33,509,920 | 35,934,980 | 41,005,560 | 57,099,140 | 58,421,900 | 56,658,220 | 52,132,176 | c 35,273,600 | 91,766,475 |
| Venezuela | | | | | | | 3,086,400 | 2,865,980 | | | |
| Total Central America and South America | 82,555,200 | 89,555,200 | 125,221,280 | 122,134,840 | 126,103,120 | 129,630,480 | 153,881,040 | 156,085,680 | 148,294,622 | 156,705,172 | 258,059,453 |
| Cape Colony | 8,825,600 | 9,475,200 | 9,920,700 | 10,361,620 | 9,920,700 | 15,652,660 | 8,597,940 | 7,275,180 | 6,889,375 | c 59,524,200 | c 110,230,000 |
| Namaqualand | 5,824,000 | 5,600,000 | 5,291,040 | 5,291,040 | 5,511,500 | | 5,511,500 | 5,511,500 | 5,132,308 | | |
| Other Africa | 985,600 | 156,800 | | 17,857,260 | 18,518,640 | 22,486,920 | 22,486,920 | 37,698,660 | 41,186,337 | | |
| Total Africa | 15,635,200 | 15,232,000 | 15,211,740 | 33,509,920 | 33,950,840 | 38,139,580 | 36,596,360 | 50,485,340 | 53,208,020 | 59,524,200 | 110,230,000 |
| Japan | 95,737,600 | 109,614,400 | 96,341,020 | 105,379,880 | 102,954,820 | 123,237,140 | 146,826,360 | 161,376,720 | 150,040,666 | 166,259,909 | 179,189,888 |
| Australia | 81,200,000 | 92,400,000 | 88,404,460 | 77,161,000 | 90,388,600 | 93,695,500 | 105,379,880 | 104,277,580 | 82,870,914 | 71,675,955 | c 77,161,000 |
| Grand total | 1,595,553,188 | 1,589,410,905 | 1,682,864,613 | 1,874,065,787 | 1,902,391,298 | 1,958,000,631 | 2,259,158,107 | 2,198,733,223 | 2,068,973,915 | 2,346,300,299 | 3,106,995,660 |

a Figures compiled by Henry R. Merton & Co. (Ltd.), reduced to pounds, except that the official figures for the production of the United States and Canada are inserted.
b Figures reported by "Mineral Industry," reduced to pounds, except that the official figures for the production of the United States and Canada are inserted.
c Estimated.

## GENERAL CONDITION OF THE INDUSTRY.

The copper-producing plants of the country were operating at capacity at the beginning of 1916, and under the spur of active demand and unusually high prices a general enlargement took place. There was comparatively little interruption from labor troubles or other causes, and the combined result was by far the largest output in the history of the domestic copper industry.

The average cost per pound of copper showed a decrease in 1915 from 1914, owing both to the plants being worked more nearly at capacity and to the relatively slight increase in cost of labor and material. In 1916 the cost of both labor and material had advanced and this advance was reflected in the increased cost of copper. In 1915 the average cost of copper per pound, as given in the annual reports of the companies giving this item, was about 8 cents; in 1916 the average was 11.3 cents. The figures for both years are below the actual average cost of all copper produced, but the increase in 1916 doubtless represents approximately the increase in average cost.

The average price received for copper in 1916 as reported by the selling agencies was 24.58 cents a pound, as compared with about 17.5 cents in 1915—an increase in 1916 of about 7 cents a pound. The profit per pound of copper was probably at least 3.5 cents greater than in 1915, and this was reflected in the large earnings of the principal copper companies.

The effect of the remodeling of plants to improve metallurgic practices, which has been in progress for the last few years, was shown in the recoveries in 1916. For several years prior to 1915 the quantity of copper recovered per ton of ore showed a steady decrease. This was caused by the treating of constantly increasing quantities of low-grade concentrating ore. In 1915 and 1916, in spite of large increase in the concentrating ore treated there was an increase in the average quantity of copper recovered per ton of ore, and this in spite of the fact that some plants were operated beyond their capacity for greatest metallurgic efficiency.

Exports of metallic copper were larger than in 1915, but were still below those of 1914 and 1913. Domestic consumption, however, showed a large increase and, as in 1915, much of this was exported in manufactured form. As the capacity of British and French munitions plants increased, more raw materials and less manufactured products were exported.

At the end of 1916 the capacity for producing copper in the United States was larger than it has ever been and was increasing.

## PRODUCTION.

### IMPORTANCE OF LARGE AND SMALL MINES IN THE PRODUCTION OF COPPER.

Since the United States entered the world war the discussion of price fixing by the Government and its effect on the output of various products has received much attention.

In the copper industry much weight has been attached by those favoring a high price to the necessity of encouraging the output from small producers. Various estimates have been made of the impor-

tance of the small producers and the effect that would result from an increase or decrease in the price of copper. It seems desirable, for an understanding of this problem, to have more facts, and the following table showing the output of copper in the United States for 1913 and 1916, graded according to the quantity produced by the contributing mines, has been prepared as a contribution of facts to the solution of the problem.

The production of copper has been divided into that derived from mines producing ore in which copper was the most valuable constituent and that from mines in which copper was subordinate in value to other metals. The price of copper would be of prime importance to the former but not to the latter. There are some mines whose production is not readily susceptible of such a division, as they produce some ore chiefly valuable for copper and some ore in which copper is a minor constituent. Such mines, however, are of little importance as compared with the total of producers.

The production of copper from copper ores has been subdivided into that from producers contributing annually less than 1,000,000 pounds, between 1,000,000 and 5,000,000 pounds, between 5,000,000 and 10,000,000 pounds, and more than 10,000,000 pounds. A "producer" may represent the output of a single mine, as the United Verde, or it may be the production of a group of mines in a single district under the same management, as the Anaconda mines at Butte. In Michigan mines with individual organizations have been considered as producers, although they form parts of a group, as those under Calumet & Hecla management. The year 1913 was chosen as one in which there were no unusual disturbing factors for the industry as a whole and as representing a year of about average price, and 1916 as one of exceptionally high prices. The average price received for copper in 1913 was about 15.5 cents a pound and in 1916 it was about 24.6 cents a pound.

In attempting to determine the effect of high selling price on increased production it should be recalled that in 1913 many of the large companies were increasing and planning to increase their capacity so that copper could be turned out in as large quantity as there was probability that it could be marketed. The profits resulting from the operations at that time were apparently ample incentive for the enlargement of existing plants and for the starting of new enterprises.

Another factor that must be considered is the change in metallurgy from 1913 to 1916, especially the development of the flotation process, which has made possible the profitable operation of mines that had not been profitable before and which has largely increased the metal recovery from ores that had been treated with profit by less effective methods.

*Copper produced in the United States, 1913 and 1916, classified by mines in which copper was the most important metal and by those in which it was a by-product.*

| | Mines of which copper is the most important product. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Less than 1,000,000 pounds. | | 1,000,000 pounds and less than 5,000,000 pounds. | | 5,000,000 pounds and less than 10,000,000 pounds. | | 10,000,000 pounds or more. | |
| | Number of mines. | Quantity (pounds). | Number of mines. | Quantity (pounds). | Number of mines. | Quantity (pounds). | Number of mines. | Quantity (pounds). |
| 1913 | 492 | 22,960,797 | 36 | 93,088,952 | 11 | 78,178,256 | 24 | 1,004,634,383 |
| 1916 | 914 | 50,497,875 | 55 | 131,708,061 | 11 | 84,123,586 | 31 | 1,711,395,262 |
| Increase | 422 | 27,537,078 | 19 | 38,619,109 | 0 | 5,945,330 | 7 | 706,760,879 |
| Percentage of increase | 85.8 | 120.0 | 52.8 | 41.5 | 0 | 7.6 | 29.2 | 70.4 |
| Percentage of production: | | | | | | | | |
| 1913 | ..... | 1.86 | ..... | 7.53 | ..... | 6.33 | ..... | 81.31 |
| 1916 | ..... | 2.52 | ..... | 6.57 | ..... | 4.19 | ..... | 85.32 |
| Percentage of total increase | 93.55 | 3.53 | 4.22 | 4.95 | 0 | .76 | 1.55 | 90.74 |

| | Total copper mines. | | Mines of which copper is not the most important product. | | Total. | |
|---|---|---|---|---|---|---|
| | Number of mines. | Quantity (pounds). | Number of mines. | Quantity (pounds). | Number of mines. | Quantity (pounds). |
| 1913 | 563 | 1,198,862,388 | 883 | 36,707,339 | 1,446 | 1,235,569,727 |
| 1916 | 1,011 | 1,977,724,784 | 837 | 28,150,528 | 1,848 | 2,005,875,312 |
| Increase or decrease | +448 | +778,862,396 | −46 | −8,556,811 | +402 | +770,305,585 |
| Percentage of increase or decrease | +79.6 | +64.9 | −5.2 | −23.3 | 27.8 | 62.3 |
| Percentage of production: | | | | | | |
| 1913 | ..... | ..... | ..... | 2.97 | ..... | 100.0 |
| 1916 | ..... | ..... | ..... | 1.40 | ..... | 100.0 |

An inspection of the table shows that a large number of mines yield copper, but that the larger part of the production is from a comparatively small number of producers.

In 1913 more than 81 per cent of the output was made by 24 producers, each of which made more than 10,000,000 pounds of copper; in 1916 a total of 31 such mines produced more than 85 per cent of the output. Mines that produced less than 1,000,000 pounds numbered 492 in 1913 and 914 in 1916 and produced, respectively, 1.86 and 2.52 per cent of the output for those years.

It is noteworthy that from 1913 to 1916 the percentage of the production from copper mines that produced more than 10,000,000 pounds each increased about 4 per cent, and that the percentage from copper mines that produced less than 10,000,000 pounds each decreased about 2.5 per cent.

The copper mines that produced 10,000,000 pounds each represented only 1.55 per cent of the increase in number of mines, although they yielded 90.74 per cent of the increase in copper, whereas the mines that produced less than 1,000,000 pounds each represented 93.55 per cent of the increase in number and only 3.53 per cent of the increase in production.

The figures shown in the table, in connection with other facts, suggest certain questions.

To what extent has the increase in production since 1913 been due to the increase in the price of copper? Is sufficient labor available to work all mines to the maximum capacity? If not, could the available labor be employed more effectively in the large or in the small mines, by the high-cost or the low-cost producers? To what extent has the high price encouraged the employment of labor and the use of supplies in unproductive prospecting? If the mines that produce copper at a moderate cost had ample labor and supplies, could they turn out all the copper required? Can an increased production now be attained by further increasing the price and encouraging the employment of labor and use of supplies in small mines and prospects, or should such dissemination of labor and supplies be discouraged? Is the small producer really any better off than in 1913? If not, should the upward tendency in prices in the industries (of course, no one industry can stand alone) be encouraged or discouraged? Is the supply of ore in developed mines sufficient to warrant the discouragement of prospecting for the period of the war and to warrant the utilization of available labor and supplies where they will produce most, or would such a course endanger our future supply? What effect on the efficiency of labor has resulted from the increased price of copper and the resulting increased wage? Is the laborer in the industry any better off, or has the cost of living kept pace with increased wages?

These and similar questions have occurred to everyone interested in industrial life during the last few years.

The data presented in the table and in other parts of this report have a bearing on some of these questions, which are briefly discussed; as to others, sufficient data are not at hand to make discussion profitable, though their importance should not be overlooked and their discussion by those in possession of adequate data would be of great value.

It is needless to say that in any attempt to answer many of the questions that arise general conditions, not those in a single industry, must be considered. If the prices of all his supplies, including labor, are increased, the producer of any commodity is entitled to raise the price of his product. The copper industry is one that has felt both the advantages and the disadvantages of the upward trend and is vitally interested in what the future trend is to be.

Brief consideration of some of the questions follows. To what extent has the increase in production of copper been due to the increase in the price of copper? The increased price has evidently resulted in the addition of many mines to the producing list. If there is ample labor and supplies for all, it is evident that the output of those that were thus added is an increase due to increased price. The profit on most of the production in 1913 was sufficient to induce the enlargement of plants as fast as the demand for copper warranted, and such enlargements and new enterprises were in progress during 1913 and till the war broke out in 1914. When in 1915 it became evident that large quantities of copper could be marketed, expansion was seemingly pushed as rapidly as possible and doubling the price could not have further accelerated it. Lack of supplies was then the greatest factor retarding expansion.

It seems reasonable to assume that, if the supplies then available had been used only by producers who could have quickly and efficiently utilized them in producing copper, the output would have increased more rapidly than by having the supplies in part utilized in mines in which the resulting production was deferred, and in mines which proved to be inefficient, and indeed in many prospects which have never produced. The high price, of course, was the great encouragement to the equipment and operation of properties whose eventual status as producers was uncertain.

Is there sufficient labor available to work all mines to maximum capacity? If not, could it be employed most effectively in the large or in the small mines, in the high-cost or in the low-cost mines? There has undoubtedly been an increasing shortage of labor that has been accentuated by the draft, and the copper industry in common with others has felt the shortage, and in some places severely. High wages have doubtless attracted labor from other industries, but such transfers in a time of general shortage may not work to the general good. So far as there is a shortage, there can be no question that the small high-cost mines must be the ones to close if production is to be maintained at a maximum.

To what extent has the high price encouraged the employment of labor and the use of supplies in unproductive prospecting when they could have been productively employed? No quantitative answer to this question is possible, as not even a record of the number of the unproductive properties operated is available. All who are familiar with the conditions, however, are aware that the increase in the price of copper made it easy to obtain money for prospecting, and that prospecting seemed to be limited only by the ability to procure labor and supplies. There can be no doubt that a very considerable increase in the labor unproductively employed has resulted from the increase in the price of copper.

If the mines that produce copper at a moderate cost had ample labor and supplies, could they turn out all the copper required? There is lack of sufficient facts—available at least to the writer—to warrant any positive answer to this question, particularly as to the price that is essential to bring out the necessary production. Most of the large mines, and indeed many of the small ones, are not high-cost producers, and but a comparatively small part of the output has been derived from what are classed as high-cost producers. When account is taken of the rapid increase in production during 1915, 1916, and the first half of 1917, mostly by the large producers as shown in the table, there seems little doubt that all essential requirements can be met by mines that produce at a moderate cost, provided that they are not hampered by lack of labor or supplies.

Can an increased production now be attained by further increasing the price and encouraging the employment of labor and use of supplies in small mines and prospects, or can this result be attained by discouraging such dissemination of the available labor and supplies? The answer to this question is based on those that go before. With a limited labor supply but one conclusion seems possible—namely, that the well-equipped mines with adequate transportation facilities must have ample labor and supplies if maximum production is to be maintained.

Is the small producer really any better off than in 1913? If not, should the upward tendency in prices and costs in the industries be encouraged or discouraged? Data for answering this question are not at hand, as few of the financial reports of the small producers are available. If we may judge from the general discussions in the financial and trade journals, the small producer is now hard pressed, although in 1913 he received no sympathy and apparently was not in need of it. There is no doubt that many of the small producers were making good profits in both periods, although there will always be considerable production at little or no profit and some production at a loss, no matter what the price of copper may be. If an increase of 60 per cent in the price of copper has worked a relative hardship to the small producer, can another 5 or 10 per cent increase be expected to improve his condition?

Is the supply of ore in developed mines sufficient to warrant the discouragement of prospecting for the period of the war and to warrant the utilization of available labor and supplies where they will produce most, or would such a course endanger our future supply? It is well recognized in mine management that prospecting should be kept well ahead of extraction of ore, and the same holds true for the whole industry. There are times, however, when it is deemed wise to restrict prospecting and to concentrate on extraction. At present there is more copper ore actually developed or reasonably assured in mines already equipped than at any other time in the history of the industry. Unlike some of our gold mines, the copper mines are not likely to give out unexpectedly. Of our great copper districts, many of which have been worked for 30 years or more, practically every one is making the greatest production in its history, and there is no reason to expect speedy exhaustion. It would seem safe, then, to rely on the known sources of supply for the next few years and to postpone prospecting until labor is available that is not so vitally needed for other purposes.

What is the proper price for copper now can be determined only by the consideration of many factors that are not presented here and are not available to the writer. Under present conditions of shortage of labor and supplies, however, there seems ample reason for doubting the accuracy of the frequently repeated assertion that an increase in price will further increase the production. It is obviously the duty of every industry at this time to carry on its operations with the minimum of labor and supplies to produce the essential results, and if this is to be accomplished in the copper industry without direct regulation, the operation of producers that require an excessive amount of labor or supplies should not be unduly encouraged.

## SMELTER PRODUCTION.

*Copper produced in the United States from 1845 to 1916, inclusive.*

[Values rounded.]

| Year. | Quantity. | Increase. | Value. | Year. | Quantity. | Increase. | Value. |
|---|---|---|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | | | *Pounds.* | *Pounds.* | |
| 1845 | 224,000 | ..... | $45,000 | 1882 | 90,646,232 | 18,966,232 | $17,313,000 |
| 1846 | 336,000 | 112,000 | 57,000 | 1883 | 115,526,053 | 24,879,821 | 19,062,000 |
| 1847 | 672,000 | 336,000 | 124,000 | 1884 | 144,946,653 | 29,420,600 | 18,843,000 |
| 1848 | 1,120,000 | 448,000 | 218,000 | 1885 | 165,875,483 | 20,928,830 | 17,915,000 |
| 1849 | 1,568,000 | 448,000 | 349,000 | 1886 | 157,763,043 | a8,112,440 | 17,512,000 |
| 1850 | 1,456,000 | a112,000 | 320,000 | 1887 | 181,477,331 | 23,714,288 | 25,044,000 |
| 1851 | 2,016,000 | 560,000 | 334,000 | 1888 | 226,361,466 | 45,440,942 | 38,029,000 |
| 1852 | 2,464,000 | 448,000 | 542,000 | 1889 | 226,775,962 | 414,496 | 30,615,000 |
| 1853 | 4,480,000 | 2,016,000 | 985,000 | 1890 | 259,763,092 | 32,987,130 | 40,523,000 |
| 1854 | 5,040,000 | 560,000 | 1,108,000 | 1891 | 284,121,764 | 24,358,672 | 36,368,000 |
| 1855 | 6,720,000 | 1,680,000 | 1,814,000 | 1892 | 341,998,679 | 60,876,915 | 40,020,000 |
| 1856 | 8,960,000 | 2,240,000 | 2,419,000 | 1893 | 329,354,398 | a15,644,281 | 35,570,000 |
| 1857 | 10,752,000 | 1,792,000 | 2,688,000 | 1894 | 354,188,374 | 24,833,976 | 33,648,000 |
| 1858 | 12,320,000 | 1,568,000 | 2,833,000 | 1895 | 380,613,404 | 26,425,030 | 40,726,000 |
| 1859 | 14,112,000 | 1,792,000 | 3,104,000 | 1896 | 460,061,430 | 79,448,026 | 49,687,000 |
| 1860 | 16,128,000 | 2,016,000 | 3,709,000 | 1897 | 494,078,274 | 34,016,844 | 59,289,000 |
| 1861 | 16,800,000 | 672,000 | 3,696,000 | 1898 | 526,512,987 | 32,434,713 | 65,288,000 |
| 1862 | 21,160,000 | 4,360,000 | 4,655,000 | 1899 | 568,666,921 | 42,153,934 | 97,242,000 |
| 1863 | 19,040,000 | a2,120,000 | 6,473,000 | 1900 | 606,117,166 | 37,450,245 | 100,615,000 |
| 1864 | 17,920,000 | a1,120,000 | 8,422,000 | 1901 | 602,072,519 | a4,044,647 | 100,546,000 |
| 1865 | 19,040,000 | 1,120,000 | 7,473,000 | 1902 | 659,508,644 | 57,436,125 | 80,460,000 |
| 1866 | 19,936,000 | 896,000 | 6,828,000 | 1903 | 698,044,517 | 38,535,873 | 95,632,000 |
| 1867 | 22,400,000 | 2,464,000 | 5,682,000 | 1904 | 812,537,267 | 114,492,750 | 104,005,000 |
| 1868 | 25,984,000 | 3,584,000 | 5,976,000 | 1905 | 888,784,267 | 76,247,000 | 138,650,000 |
| 1869 | 28,000,000 | 2,016,000 | 6,790,000 | 1906 | 917,805,682 | 29,021,415 | 177,136,000 |
| 1870 | 28,224,000 | 224,000 | 5,977,000 | 1907 | 868,996,491 | a48,809,191 | 173,799,000 |
| 1871 | 29,120,000 | 896,000 | 7,023,000 | 1908 | 942,570,721 | 73,574,230 | 124,419,000 |
| 1872 | 28,000,000 | a1,120,000 | 9,956,000 | 1909 | 1,092,951,624 | 150,380,903 | 142,084,000 |
| 1873 | 34,720,000 | 6,720,000 | 9,721,000 | 1910 | 1,080,159,509 | a12,792,115 | 137,180,000 |
| 1874 | 39,200,000 | 4,480,000 | 8,624,000 | 1911 | 1,097,232,749 | 17,073,240 | 137,154,000 |
| 1875 | 40,320,000 | 1,120,000 | 9,152,000 | 1912 | 1,243,268,720 | 146,035,971 | 206,139,000 |
| 1876 | 42,560,000 | 2,240,000 | 8,937,000 | 1913 | 1,224,484,098 | a18,784,622 | 189,795,000 |
| 1877 | 47,040,000 | 4,480,000 | 8,937,000 | 1914 | 1,150,137,192 | a74,346,906 | 152,968,000 |
| 1878 | 48,160,000 | 1,120,000 | 7,994,000 | 1915 | 1,388,009,527 | 237,872,335 | 242,902,000 |
| 1879 | 51,520,000 | 3,360,000 | 9,582,000 | 1916 | 1,927,850,548 | 539,841,021 | 474,288,000 |
| 1880 | 60,480,000 | 8,960,000 | 12,943,000 | | | | |
| 1881 | 71,680,000 | 11,200,000 | 13,046,000 | | 23,311,934,787 | ..... | 3,648,002,000 |

a Decrease.

The figures in this table, except those for 1916, are taken from the volumes of Mineral Resources of the United States. Statistics from 1882 to 1916, inclusive, are based on the returns to the United States Geological Survey by the copper-producing companies. Figures for the years prior to 1882 were compiled by the Survey from the best sources available. Reliable figures for years previous to 1845 are not obtainable. The year 1845, however, marks the entrance of the Lake Superior district into the ranks of producers and is really the beginning of important production of copper in this country. The industry has shown a steady and, since 1880 when Arizona and Montana became large producers, a very rapid growth.

Only seven times since 1880 has the annual production shown a decrease from that of the preceding year and in every instance the decrease has been slight and, with the exception of 1913, has been more than recovered in the following year. The years showing a decrease are 1886, 1893, 1901, 1907, 1910, 1913, and 1914. In several other years the increase has been slight. In most years in which there has been a decrease it may be attributed to a general condition of financial and business depression which has resulted in a decrease in the demand for copper and other materials necessary to the expansion of industries. In three years a slight decrease appears to

have been due to the fact that the producing capacity of the country had been increased out of proportion to the demand for domestic consumption and export, and a temporary curtailment in production became necessary to permit the absorption of accumulated stocks. This, coupled with attempts at artificial control of prices, appears to have been the case in 1886 and also in 1901, and the decrease in production in 1910 may be attributed to a similar cause. The large increase in 1912 was due to the output from mines that reached the producing stage during 1912 or had previously made but relatively small production.

The total decrease in 1913 was really less than that of Michigan alone in that year, which was due to labor troubles. The decrease in 1914 can be attributed entirely to the European war, and the increase in 1915 and 1916, which in 1916 was greater than the total production of any year before 1899, is to be accounted for in the same manner.

The figures of smelter production in 1916 are based on returns made confidentially to the United States Geological Survey by all known smelting companies handling copper-bearing materials from the United States. To all companies and officials who have aided in furnishing this information and have given valuable time to answering inquiries concerning distribution of the output sincere thanks are extended. The following list gives the name of the owning or operating companies, the location, and the final copper product of smelting and refining plants treating material from the United States during 1916. It does not include lead and zinc plants that recovered copper as a by-product from mixed ores. Lists of lead and zinc smelters can be found in the reports on those metals.

*Copper smelting plants that treated materials from the United States in 1916.*

| Location. | Company. | Final copper product. |
|---|---|---|
| Arizona: | | |
| Clifton | Arizona Copper Co | Blister. |
| Do | Shannon Copper Co | Do. |
| Douglas | Calumet & Arizona Mining Co | Do. |
| Do | Copper Queen Consolidated Mining Co | Do. |
| Globe | Old Dominion Copper Mining & Smelting Co | Do. |
| Hayden | American Smelting & Refining Co | Do. |
| Humboldt | Consolidated Arizona Smelting Co | Do. |
| Clarkdale | United Verde Copper Co | Do. |
| Miami | International Smelting & Refining Co | Do. |
| Morenci | Detroit Copper Mining Co | Do. |
| Sasco | American Smelting & Refining Co | Do. |
| California; | | |
| Campo Seco | Penn Mining Co | Matte. |
| Kennett | Mammoth Copper Mining Co | Blister. |
| Martinez | Mountain Copper Co | Do. |
| Colorado: | | |
| Gunnison County | Vulcan Mines & Smelters Co | Matte. |
| Ouray | Wanakah Mining Co | Do. |
| Salida | Ohio & Colorado Smelting & Refining Co | Do. |
| Maryland: | | |
| Baltimore | Baltimore Copper Smelting & Rolling Co | Electrolytic. |
| Michigan: | | |
| Hancock | Lake Superior Smelting Co | Anodes and Lake. |
| Do | Quincy Mining Co | Do |
| Houghton | Michigan Smelting Co | Do |
| Hubbell | Calumet & Hecla Mining Co | Do. |
| Montana: | | |
| Anaconda | Anaconda Copper Mining Co | Blister. |
| Butte | East Butte Copper Mining Co | Do. |
| Great Falls | Anaconda Copper Mining Co | Blister and electrolytic. |
| Nebraska: | | |
| Omaha | American Smelting & Refining Co | Blister. |
| Nevada: | | |
| McGill | Nevada Consolidated Copper Co | Do. |

*Copper smelting plants that treated materials from United States in 1916*—Continued.

| Location. | Company. | Final copper product. |
|---|---|---|
| New Jersey:[a] | | |
| Chrome | United States Metals Refining Co. | Electrolytic and casting. |
| Maurer | American Smelting & Refining Co. | Electrolytic. |
| Newark | Balbach Smelting & Refining Co. | Electrolytic and casting. |
| Perth Amboy | Raritan Copper Works | Electrolytic. |
| New Mexico: | | |
| San Pedro | Santa Fe Gold & Copper Mining Co | Matte. |
| New York: | | |
| Laurel Hill | Nichols Copper Co. | Electrolytic and casting. |
| Tennessee: | | |
| Copperhill | Tennessee Copper Co. | Blister. |
| Isabella | Ducktown Sulphur, Copper & Iron Co. (Ltd.) | Matte. |
| Texas: | | |
| El Paso | American Smelting & Refining Co. | Blister. |
| Utah: | | |
| Garfield | Garfield Smelting Co. | Do. |
| International | International Smelting & Refining Co. | Do. |
| Virginia: | | |
| West Norfolk | Norfolk Smelting Co. | Do. |
| Washington: | | |
| Tacoma | Tacoma Smelting Co. | Blister and electrolytic. |
| British Columbia: | | |
| Anyox | Granby Consolidated Mining, Smelting, & Power Co. | Blister. |
| Grand Forks | do. | Do. |
| Do. | do. | Do. |
| Greenwood | British Columbia Copper Co. (Ltd.) | Do. |
| Trail | Consolidated Mining & Smelting Co. of Canada | Matte. |

[a] This list does not include a smelter in New Jersey and one in Pennsylvania, both of which make blister from material solely of foreign origin.

During the year 43 copper smelting and refining plants treated material from the United States; of these, 38 were domestic plants and 5 were foreign.

The figures of production represent the actual smelter recovery. For Michigan it is the sum of furnace-refined copper and copper cast into anodes for electrolytic refining. As to blister copper, the figures represent the fine copper content. Some casting copper is produced direct from ore and matte, and this is included in the smelter production.

## MINE RETURNS.

The figures of mine production are based on reports furnished to the United States Geological Survey by all mines producing copper in 1916. These mines reported 2,005,875,312 pounds of copper, or 78,000,000 pounds more than the smelters. The mines and smelters of several of the large copper producers are under the same management and their production is reported on the same basis. In the case of mines that ship to custom smelters or have only matting furnaces and ship their matte for conversion there is likely to be considerable discrepancy, as the mines may report a considerable quantity that has not reached the stage of blister by the close of the year and is consequently not included in the smelter production, or material that was reported by the mines in one year may be treated by the smelters the following year. This discrepancy is more pronounced if a market curtailment of production occurs at the beginning or at the close of the year, so that there is not the balance of overlap that occurs if the industry is in normal condition throughout the year. Considerable copper is recovered by the smelters from ores that are treated primarily for other metals, the copper content being so low that it is not paid for, and, consequently, is not always reported by the mines.

*Copper produced from domestic ores as reported by mines, smelters, and refineries, 1906–1916, in pounds.*

| Year. | Mine. | Smelter. | Refinery. |
|---|---|---|---|
| 1906 | 916,971,387 | 917,805,682 | 897,382,387 |
| 1907 | 847,151,015 | 868,996,491 | 826,622,390 |
| 1908 | 956,840,578 | 942,570,721 | 919,111,414 |
| 1909 | 1,126,521,126 | 1,092,951,624 | 1,065,564,921 |
| 1910 | 1,088,237,432 | 1,080,159,509 | 1,071,894,876 |
| 1911 | 1,114,764,197 | 1,097,232,749 | 1,101,270,803 |
| 1912 | 1,249,094,891 | 1,243,268,720 | 1,203,676,895 |
| 1913 | 1,235,569,727 | 1,224,484,098 | 1,236,823,913 |
| 1914 | 1,148,431,437 | 1,150,137,192 | 1,210,423,189 |
| 1915 | 1,488,071,528 | 1,388,009,527 | 1,387,705,523 |
| 1916 | 2,005,875,312 | 1,927,850,548 | 1,888,752,199 |

The difference between the smelter and the refinery production is accounted for entirely by an increase in the stocks of blister copper plus the copper content of bluestone produced and the loss in refining.

It appears that although theoretically the output reported by the mines should be considerably in excess of that reported by the smelters, this difference in the last 10 years has been nearly balanced by copper recovered from lead, zinc, gold, silver, and sulphur ores, which carry so little copper that it is not paid for, and consequently has not usually been reported by the mines.

## PRODUCTION BY STATES.

Twenty-three States and Territories contributed to the production of copper in 1916. The subjoined table shows the mine and the smelter output of individual States for 1915 and 1916.

According to smelter returns, the four leading States—Arizona, Montana, Michigan, and Utah—produced 80 per cent of the total output in 1916, as in 1915; and the eight leading States, including Alaska, Nevada, New Mexico, and California, produced 97.88 per cent of the total output in 1916.

*Copper produced in the United States in 1915 and 1916, according to smelter and mine returns, in pounds.*

| State. | 1916. | | | | 1915. | |
|---|---|---|---|---|---|---|
| | Rank. | Percentage of total. | Smelter returns. | Mine returns. | Smelter returns. | Mine returns. |
| Alaska | 5 | 5.90 | 113,823,064 | 119,854,839 | 70,695,286 | 86,509,312 |
| Arizona | 1 | 36.04 | 694,847,307 | 721,833,169 | 432,467,690 | 459,972,295 |
| California | 8 | 2.25 | 43,400,876 | 55,897,118 | 37,658,444 | 40,751,625 |
| Colorado | 10 | .49 | 9,536,193 | 8,624,081 | 7,272,178 | 7,112,537 |
| Georgia | 16 | .04 | 803,699 | 803,699 | ..... | ..... |
| Idaho | 11 | .38 | 7,248,794 | 8,478,281 | 6,217,728 | 6,978,713 |
| Michigan | 3 | 13.99 | 269,794,531 | 273,692,525 | 238,956,410 | 265,283,378 |
| Missouri | 17 | .02 | 377,575 | 386,300 | 306,406 | 402,160 |
| Montana | 2 | 18.27 | 352,139,768 | 352,928,373 | 268,261,040 | 267,231,014 |
| Nevada | 6 | 5.23 | 100,816,724 | 105,116,813 | 67,757,322 | 68,636,370 |
| New Jersey | 21 | ..... | 4,115 | ..... | ..... | ..... |
| New Mexico | 7 | 4.14 | 79,863,439 | 92,747,289 | 62,817,234 | 76,788,366 |
| North Carolina | 20 | ..... | 5,961 | 9,800 | 33,383 | 17,170 |
| Oregon | 13 | .13 | 2,433,567 | 3,581,886 | 797,471 | 451,172 |
| Pennsylvania, Maryland, and Virginia | 15 | .06 | 1,194,012 | 1,337,580 | 65,434 | 629,855 |
| Tennessee | 9 | .76 | 14,556,278 | 14,679,794 | 18,205,308 | 18,046,010 |
| Texas | 19 | ..... | 86,463 | 99,569 | 38,971 | 42,491 |
| Utah | 4 | 12.05 | 232,335,950 | 240,275,222 | 175,177,695 | 187,671,188 |
| Vermont | 18 | .02 | 324,400 | 273,430 | 23,995 | 79,700 |
| Washington | 12 | .13 | 2,473,481 | 2,645,022 | 903,661 | 1,020,926 |
| Wyoming | 14 | .09 | 1,784,351 | 2,610,622 | 351,871 | 447,246 |
| | ..... | ..... | 1,927,850,548 | 2,005,875,312 | 1,388,009,527 | 1,488,071,528 |

In the distribution of the blister output to the States of origin it is necessary to have reports not only from blister producers, but also from matte smelters, as the matte is credited by the smelter that converts it to the State from which it was received, although the matte smelter may have received its ores from several States. In the adjustment of the products of these matte smelters slight errors in the distribution of the blister production are probably introduced. Likewise, the distribution of copper derived from zinc residues is subject to some error.

The following table shows the production from 1907 to 1916. The report for 1915 contains a table showing the production of copper by the different States from 1845:

*Copper produced in the United States, 1907–1916, in pounds.*

| State. | 1907 | 1908 | 1909 | 1910 | 1911 |
|---|---|---|---|---|---|
| Alaska | 7,034,763 | 4,438,836 | 4,057,142 | 4,311,026 | 22,314,889 |
| Arizona | 256,778,437 | 289,523,267 | 291,110,298 | 297,250,538 | 303,202,532 |
| California | 33,696,602 | 39,643,835 | 53,568,708 | 45,760,200 | 35,835,651 |
| Colorado | 13,998,496 | 13,943,878 | 11,485,631 | 9,307,497 | 9,791,861 |
| Idaho | 9,707,299 | 7,256,086 | 7,096,132 | 6,877,515 | 4,514,116 |
| Michigan | 219,131,503 | 222,289,584 | 227,005,923 | 221,462,984 | 218,185,236 |
| Montana | 224,263,789 | 252,509,122 | 314,900,279 | 283,078,516 | 271,816,098 |
| Nevada | 1,998,164 | 12,241,372 | 53,849,281 | 64,494,640 | 65,561,015 |
| New Mexico | 10,140,140 | 4,991,351 | 5,031,136 | 3,784,809 | 2,860,400 |
| Oregon | 518,694 | 271,191 | 245,403 | 22,022 | 125,943 |
| Utah | 66,418,370 | 71,370,370 | 101,241,114 | 125,185,455 | 142,340,215 |
| Washington | 122,263 | 162,201 | 120,611 | 65,021 | 195,503 |
| Wyoming | 3,026,004 | 2,416,197 | 433,672 | 217,127 | 130,499 |
| Eastern States and unapportioned | 22,161,967 | 21,513,431 | 22,806,294 | 18,342,359 | 20,358,791 |
| | 868,996,491 | 942,570,721 | 1,092,951,624 | 1,080,159,509 | 1,097,232,749 |

| State. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Alaska | 31,926,209 | 23,421,070 | 24,985,847 | 70,695,286 | 113,823,064 |
| Arizona | 359,322,036 | 404,278,809 | 382,449,922 | 432,467,690 | 694,847,307 |
| California | 31,516,471 | 32,492,265 | 29,784,173 | 37,658,444 | 43,400,876 |
| Colorado | 7,963,520 | 9,052,104 | 7,316,066 | 7,272,178 | 9,536,193 |
| Idaho | 7,182,185 | 8,711,490 | 5,875,305 | 6,217,728 | 7,248,794 |
| Michigan | 231,112,228 | 155,715,286 | 158,009,748 | 238,956,410 | 269,794,531 |
| Montana | 308,794,483 | 285,724,467 | 236,805,845 | 268,263,040 | 352,139,768 |
| Nevada | 83,413,900 | 85,209,536 | 60,122,904 | 67,757,322 | 100,816,724 |
| New Mexico | 29,170,400 | 50,196,881 | 64,204,703 | 62,817,234 | 79,863,439 |
| Oregon | 311,860 | 77,812 | 5,599 | 797,471 | 2,433,567 |
| Utah | 132,150,052 | 148,057,450 | 160,589,660 | 175,177,696 | 232,335,950 |
| Washington | 1,069,938 | 732,742 | 683,602 | 903,661 | 2,473,481 |
| Wyoming | 25,060 | 362,235 | 17,082 | 351,871 | 1,784,351 |
| Eastern States and unapportioned | 19,310,298 | 20,449,951 | 19,286,836 | 18,673,497 | 17,352,503 |
| | 1,243,268,720 | 1,224,484,098 | 1,150,137,192 | 1,388,009,527 | 1,927,850,548 |

*Copper produced in the United States, 1845–1916.*

| State. | Quantity. | Percentage. | Rank. |
|---|---|---|---|
| | *Pounds.* | | |
| Alaska | 323,979,820 | 1.39 | 9 |
| Arizona | 5,767,698,935 | 24.74 | 3 |
| California | 655,922,837 | 2.81 | 5 |
| Colorado | 257,190,893 | 1.10 | 10 |
| Idaho | 94,307,202 | .41 | 11 |
| Michigan | 6,029,777,767 | 25.87 | 2 |
| Montana | 7,055,236,907 | 30.26 | 1 |
| Nevada | 600,820,498 | 2.58 | 6 |
| New Mexico | 381,436,220 | 1.64 | 8 |
| Oregon | 6,202,036 | .03 | 14 |
| Utah | 1,649,731,595 | 7.08 | 4 |
| Washington | 8,036,708 | .03 | 13 |
| Wyoming | 28,514,518 | .12 | 12 |
| Eastern States and unapportioned | 453,178,851 | 1.94 | 7 |
| | 23,311,934,787 | 100.00 | ..... |

The totals in the preceding table show the copper output of each important copper-producing State, except those on the Atlantic coast, since the beginning of the industry. Some copper was produced in New Mexico in the early years of the last century, but the exact quantity is not known, though it was not large as measured by the present production of the metal. Prior to 1845 also a little copper was produced in Michigan and a considerable quantity in the Eastern States.

Under "Eastern States and unapportioned" is included some copper-classed as "lead desilverizers" in the earlier reports of the Survey. This should properly be credited to some of the Western States. The output of the Central States, except Michigan, is also included under this head. Statistics for the individual Eastern States have not been compiled, but it may be stated that about 319,900,000 pounds has been derived from Tennessee. To the remainder Vermont and Virginia have made the largest contributions, and some copper has been produced by practically all the Appalachian States.

It will be noted that Montana, Michigan, and Arizona stand out as the three chief copper-producing States. Montana ranks first, with more than 30 per cent of the entire output of the country; Michigan ranks second, with more than 25 per cent; and Arizona ranks third, with nearly 25 per cent. Utah, ranking next in order, has produced about 7 per cent of the total output. The three leading States have produced 80 per cent of the total.

It will be noted by reference to the table showing the output for 1916 that these three States still maintain their preeminence, having produced 81 per cent of the total output in 1908, 76 per cent in 1909, 74 per cent in 1910, 72 per cent in 1911 and 1912, 69 per cent in 1913, and 68 per cent in 1914, 1915, and 1916.

*Mine production of copper in the principal districts in 1916, in pounds.*

| District or region. | State. | Mine output. | Percentage of total production. | Rank. |
|---|---|---|---|---|
| Butte | Montana | 349,500,000 | 17.42 | 1 |
| Lake Superior | Michigan | 269,794,000 | 13.45 | 2 |
| Bingham | Utah | 223,619,000 | 11.15 | 3 |
| Globe-Miami | Arizona | 220,000,000 | 10.97 | 4 |
| Bisbee | do | 193,696,000 | 9.66 | 5 |
| Copper River | Alaska | 105,600,000 | 5.26 | 6 |
| Jerome | Arizona | 102,000,000 | 5.09 | 7 |
| Ely | Nevada | 93,044,000 | 4.64 | 8 |
| Ray (Mineral Creek) | Arizona | 76,700,000 | 3.82 | 9 |
| Morenci-Metcalf | do | 75,900,000 | 3.78 | 10 |
| Santa Rita (Central) | New Mexico | 74,228,000 | 3.71 | 11 |
| Shasta County | California | 39,700,000 | 1.98 | 12 |
| Ducktown | Tennessee | 14,556,000 | .73 | 13 |
| Prince William Sound | Alaska | 10,660,000 | .53 | 14 |
| Pioneer | Arizona | 9,145,000 | .46 | 15 |
| Burro Mountain | New Mexico | 8,392,000 | .42 | 16 |
| Tintic | Utah | 7,085,000 | .35 | 17 |
| Pima | Arizona | 6,683,000 | .33 | 18 |
| Foothills Belt | California | 6,460,000 | .32 | 19 |
| Cochise | Arizona | 6,204,000 | .31 | 20 |
| Alder Creek | Idaho | 5,499,000 | .27 | 21 |
| Plumas | California | 5,150,000 | .26 | 22 |
| Banner | Arizona | 5,041,000 | .25 | 23 |
| Lordsburg | New Mexico | 4,755,000 | .24 | 24 |
| Planet | Arizona | 3,929,000 | .20 | 25 |
| Big Bug | do | 3,612,000 | .18 | 26 |
| Ketchikan | Alaska | 3,526,000 | .18 | 27 |
| Yerington | Nevada | 3,491,000 | .17 | 28 |
| Courtland (Turquoise) | Arizona | 3,250,000 | .16 | 29 |

*Mine production of copper in the principal districts in 1916, in pounds*—Continued.

| District or region. | State. | Mine output. | Percentage of total production. | Rank. |
|---|---|---|---|---|
| Ophir | Utah | 2,702,000 | 0.13 | 30 |
| San Juan-Ouray region | Colorado | 2,640,000 | .13 | 31 |
| Leadville | do | 2,620,000 | .13 | 32 |
| Santa Fe | Nevada | 2,547,000 | .13 | 33 |
| Coeur d'Alene region | Idaho | 2,200,000 | .11 | 34 |
| New Placer | New Mexico | 2,153,000 | .11 | 35 |
| Oro Grande | do | 2,077,000 | .10 | 36 |
| Helvetia | Arizona | 1,958,000 | .10 | 37 |
| Peck | do | 1,618,000 | .08 | 38 |
| Trinity | California | 1,575,000 | .08 | 39 |
| San Bernardino | do | 1,525,000 | .08 | 40 |
| Patagonia | Arizona | 1,244,000 | .06 | 41 |
| Copper Basin | do | 1,225,000 | .06 | 42 |
| Goldfield | Nevada | 1,165,000 | .06 | 43 |
| Uinta-Summit (Park City) | Utah | 1,163,000 | .06 | 44 |
| Bentley | Arizona | 1,064,000 | .05 | 45 |
| Railroad | Nevada | 1,012,000 | .05 | 46 |
| | | 1,961,707,000 | ..... | ..... |
| All others | | 44,168,000 | ..... | ..... |
| Grand total | | 2,005,875,000 | ..... | ..... |

As shown in this table, 45 districts in 1916 each produced 1,000,000 or more pounds of copper.

In the following table the statistics for the later years are compiled from reports furnished to the United States Geological Survey by the producing companies and those for the earlier years are taken mainly from reports on the several districts by members of the Survey.

*Blister copper produced in the principal districts to the end of 1916.*

| District. | State. | Date production began. | Quantity (pounds). | Percentage of total production. | Rank. |
|---|---|---|---|---|---|
| Butte | Montana | 1868 | 7,030,000,000 | 30.16 | 1 |
| Lake Superior | Michigan | 1845 | 6,029,777,236 | 25.87 | 2 |
| Bisbee | Arizona | 1880 | 2,219,556,000 | 9.52 | 3 |
| Bingham | Utah | 1896 | 1,373,119,000 | 5.89 | 4 |
| Morenci-Metcalf | Arizona | 1873 | 1,297,196,000 | 5.56 | 5 |
| Globe-Miami | do | 1881 | 903,200,000 | 3.87 | 6 |
| Jerome | do | 1883 | 855,440,000 | 3.67 | 7 |
| Ely | Nevada | 1908 | 534,124,000 | 2.29 | 8 |
| Shasta County | California | 1897 | 514,000,000 | 2.20 | 9 |
| Santa Rita (Central) | New Mexico | 1800 | 373,139,000 | 1.60 | 10 |
| Ducktown | Tennessee | 1850 | 319,966,000 | 1.37 | 11 |
| Ray (Mineral Creek) | Arizona | 1911 | 296,678,000 | 1.27 | 12 |
| Foothills Belt | California | 1862 | 135,860,000 | .58 | 13 |
| Tintic | Utah | 1880 | 131,585,000 | .56 | 14 |

Fourteen districts in eight States have each contributed in excess of 100,000,000 pounds to the copper output of the country. Five of these districts are in Arizona, two each in California and Utah, and one each in Montana, Michigan, Nevada, New Mexico, and Tennessee. Two districts stand out prominently. They are the Butte district, Mont., which has contributed nearly one-third of the output of the country, and the Lake Superior district, Mich., which has produced nearly 26 per cent of the total output. Bisbee, ranking third, has

yielded 9.52 per cent of the total. The 14 districts have yielded 94 per cent of the total output of the United States since 1845.

It is noteworthy that not a single one of the leading copper districts of the United States, several of which have been active producers for a period of 30 years or more, has been worked out or has shown a decrease in its ability to produce copper.

## QUANTITY AND YIELD OF COPPER ORES.

### COPPER-BEARING ORES PRODUCED.

The following tables show the quantity and the yield in copper of the ore produced by the mines of the United States in 1916. The figures are taken from the mines report which form a part of the annual volume Mineral Resources. The close agreement between the output as reported by the mines and the actual recovery of metal as reported by the smelters indicates that the tenor of the ores as reported by the mines is very close to the actual recovery. The classification of some of the complex western ores is difficult and more or less arbitrary. Under copper ores are classed those which contain 2.5 per cent or more of copper, as well as those which contain less than this percentage, provided their principal value is in copper. Under copper-lead and copper-zinc ores are classed complex ores in which copper is a valuable constituent. Considerable copper was reported by the mines from ores mined primarily for other metals, including siliceous gold and silver ores, lead ores, zinc ores, pyritic sulphur ores, and ores concentrated for values in other metals. No attempt has been made to compile tables showing the quantity and yield of this group of copper-bearing ores, but together with old slags and other materials they have yielded a total of 28,103,777 pounds of copper.

*Copper produced in the United States in 1916 from ores in which copper constitutes the principal value.*

| State. | Copper ore (short tons). | Copper in ore. | | Gold in ore (fine ounces). | Silver in ore (fine ounces). | Value in gold and silver, per ton. |
|---|---|---|---|---|---|---|
| | | Quantity (pounds). | Percentage. | | | |
| Alaska | 617,264 | 119,854,839 | 9.70 | 9,141.76 | 1,207,121 | 1.59 |
| Arizona | 16,491,971 | 719,702,789 | 2.18 | 105,467.71 | 5,347,893 | .35 |
| California | 933,722 | 55,792,602 | 2.97 | 44,644.11 | 1,969,783 | 2.376 |
| Colorado | 34,429 | 2,977,285 | 4.32 | 15,220.87 | 199,824 | 13.25 |
| Georgia | 31,043 | 803,699 | 1.31 | ..... | ..... | ..... |
| Idaho | 113,050 | 6,567,604 | 2.92 | 3,619.47 | 218,598 | 1.93 |
| Michigan | 12,364,114 | 273,692,525 | 1.08 | ..... | 716,640 | .228 |
| Missouri | 124 | 18,200 | 7.34 | ..... | ..... | ..... |
| Montana | 6,197,978 | 342,665,053 | 2.76 | 38,235.21 | 11,226,034 | 1.32 |
| Nevada | 4,146,956 | 104,599,510 | 1.26 | 56,850.78 | 384,393 | .34 |
| New Mexico | 3,452,910 | 87,593,495 | 1.27 | 11,336.28 | 231,091 | .11 |
| North Carolina | 165 | 9,800 | 3.00 | 8.85 | 260 | 2.14 |
| Oregon | 35,409 | 3,580,496 | 5.05 | 2,284.82 | 103,822 | 3.23 |
| Pennsylvania, Maryland, and Virginia | 204,530 | 1,337,580 | .30 | 42.81 | 1,358 | .01 |
| Tennessee | 482,495 | 14,679,794 | 1.52 | 277.63 | 94,701 | .14 |
| Texas | 2,081 | 99,569 | 2.40 | 6.01 | 26,177 | 8.34 |
| Utah | 12,676,152 | 229,960,014 | .90 | 113,396.52 | 2,633,402 | .32 |
| Vermont | 4,679 | 273,430 | 2.92 | ..... | 2,501 | .54 |
| Washington | 68,230 | 2,584,230 | 1.89 | 563.76 | 172,404 | 1.83 |
| Wyoming | 6,063 | 2,610,622 | 21.53 | 54.45 | 5,234 | .75 |
| Total and average | 57,863,365 | 1,969,403,226 | 1.70 | 401,131.04 | 24,541,236 | .42 |

*Copper ores concentrated and smelted and copper produced from each class of ore in the United States in 1916.*

| State. | Ore concentrated. | | | | Ore smelted. | | |
|---|---|---|---|---|---|---|---|
| | Quantity. | Concentrates produced. | Copper in concentrates. | Percentage of copper from ore. | Quantity. | Copper produced. | Percentage of copper from ore. |
| | *Short tons.* | *Short tons.* | *Pounds.* | | *Short tons.* | *Pounds.* | |
| Alaska | 407,520 | 51,353 | 38,977,410 | 4.78 | 209,744 | 80,877,429 | 19.28 |
| Arizona | 12,790,255 | 812,872 | 335,522,300 | 1.31 | 3,701,716 | 384,180,489 | 5.19 |
| California | 214,793 | 16,246 | 5,971,595 | 1.39 | 718,929 | 49,821,007 | 3.47 |
| Colorado | ..... | ..... | ..... | ..... | 34,429 | 2,977,285 | 4.32 |
| Georgia | ..... | ..... | ..... | ..... | 31,043 | 803,699 | 1.31 |
| Idaho | 37,141 | 1,665 | 643,042 | .87 | 75,909 | 5,924,652 | 3.90 |
| Michigan | 12,364,114 | 218,489 | 273,692,525 | 1.08 | ..... | ..... | ..... |
| Missouri | ..... | ..... | ..... | ..... | 124 | 18,200 | 7.34 |
| Montana | 5,610,477 | 1,929,232 | 290,282,734 | 2.59 | 587,501 | 52,382,319 | 4.46 |
| Nevada | 3,975,254 | 531,573 | 88,234,979 | 1.11 | 171,702 | 16,364,531 | 4.77 |
| New Mexico | 3,349,366 | 280,434 | 80,193,232 | 1.19 | 103,544 | 7,400,263 | 3.07 |
| North Carolina | ..... | ..... | ..... | ..... | 165 | 9,900 | 3.00 |
| Oregon | ..... | ..... | ..... | ..... | 35,409 | 3,580,496 | 5.05 |
| Pennsylvania, Maryland, and Virginia | 200,950 | 8,844 | 793,096 | .19 | 3,580 | 544,484 | 7.60 |
| Tennessee | ..... | ..... | ..... | ..... | 482,495 | 14,679,704 | 1.52 |
| Texas | ..... | ..... | ..... | ..... | 2,081 | 99,569 | 2.40 |
| Utah | 11,943,472 | 559,840 | 199,997,786 | .84 | 732,680 | 29,962,228 | 2.04 |
| Vermont | 3,361 | 870 | 125,058 | 1.86 | 1,318 | 148,372 | 5.63 |
| Washington | 38,652 | 3,221 | 670,723 | .87 | 29,578 | 1,913,507 | 3.22 |
| Wyoming | ..... | ..... | ..... | ..... | 6,063 | 2,610,622 | 21.53 |
| Total and average | 50,935,355 | 4,414,639 | 1,315,104,480 | 1.28 | 6,928,010 | 654,298,746 | 4.72 |

*Copper produced from copper-lead and copper-zinc ores in the United States in 1916.*

| State. | Copper-lead and copper-zinc ores. | Copper in ore. | Percentage of copper. |
|---|---|---|---|
| | *Short tons.* | *Pounds.* | |
| Arizona | 23,180 | 869,757 | 1.9 |
| Colorado | 3,129 | 299,239 | 4.8 |
| Idaho | 22 | 2,154 | 4.9 |
| Montana | 40,109 | 332,966 | .3 |
| Nevada | 2,846 | 200,213 | 3.5 |
| New Mexico | 1,061 | 108,378 | 5.1 |
| Utah | 9,645 | 559,954 | 2.9 |
| Total and average | 79,992 | 2,372,661 | 1.5 |

*Copper derived from ore classed as copper bearing (copper, copper-lead, and copper-zinc ores), and total production of copper from all sources in the United States in 1916.*

| State. | Ore treated. | Copper recovered. | Percentage of copper. | Copper from all sources including old slags, smelter cleanings, and precipitates. |
|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | | *Pounds.* |
| Alaska | 617,264 | 119,854,839 | 9.70 | 119,854,839 |
| Arizona [a] | 16,515,151 | 720,572,546 | 2.18 | 721,833,169 |
| California | 933,722 | 55,792,602 | 2.97 | 55,897,118 |
| Colorado [b] | 37,558 | 3,276,524 | 4.36 | 8,624,081 |
| Georgia | 31,043 | 803,699 | 1.30 | 803,699 |
| Idaho | 113,072 | 6,585,197 | 2.91 | 8,478,281 |
| Michigan | 12,364,114 | 273,692,525 | 1.08 | 273,692,525 |
| Missouri | 124 | 18,200 | 7.34 | [c] 386,200 |
| Montana [d] | 6,238,087 | 348,978,298 | 2.80 | 352,928,373 |
| Nevada | 4,149,802 | 104,799,723 | 1.27 | 105,116,813 |
| New Mexico [e] | 3,453,971 | 87,701,873 | 1.27 | 92,747,289 |
| North Carolina | 165 | 9,800 | 3.00 | 9,800 |
| Oregon | 35,409 | 3,580,496 | 5.05 | 3,581,886 |
| Pennsylvania, Maryland, and Virginia | 204,530 | 1,337,580 | .32 | 1,337,580 |
| Tennessee | 482,495 | 14,679,794 | 1.52 | 14,679,794 |
| Texas | 2,081 | 99,569 | 2.40 | 99,569 |
| Utah | 12,685,797 | 230,519,068 | .92 | 240,275,222 |
| Vermont | 4,679 | 273,430 | 2.92 | 273,430 |
| Washington | 68,230 | 2,584,230 | 1.89 | 2,645,022 |
| Wyoming | 6,063 | 2,610,022 | 21.53 | 2,610,622 |
| Total and average | 57,953,357 | 1,977,771,515 | 1.70 | 2,005,875,312 |

[a] Considerable copper was recovered from old slags and ores not classed as copper ores.
[b] Most of the copper from Colorado is derived from ores classed as siliceous ores and lead ores.
[c] Mainly recovered in dressing lead ores.
[d] Considerable copper was recovered as precipitates from mine waters and from ores not classed as copper ores.
[e] A large quantity of copper was derived from ores classed as lead ores, lead-zinc ores, and siliceous ores.

*Copper ores produced in the United States, 1906–1916, and average yield in copper, gold, and silver.*

| Year. | Copper ores. | Yield in copper. | Yield per ton in gold. | Yield per ton in silver. | Value per ton in gold and silver. |
|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Ounces.* | *Ounces.* | |
| 1906 | 18,000,000 | 2.50 | 0.0150 | 0.882 | $0.856 |
| 1907 | 20,253,000 | 2.11 | .0135 | .609 | .682 |
| 1908 | 22,290,986 | 2.07 | .0104 | .666 | .560 |
| 1909 | 27,932,618 | 1.98 | .0097 | .655 | .540 |
| 1910 | 28,497,238 | 1.88 | .0093 | .562 | .495 |
| 1911 | 29,988,235 | 1.82 | .0089 | .555 | .492 |
| 1912 | 35,656,414 | 1.71 | .0073 | .517 | .468 |
| 1913 | 36,336,682 | 1.67 | .0057 | .502 | .420 |
| 1914 | 35,175,541 | 1.60 | .0075 | .422 | .39 |
| 1915 | 43,404,182 | 1.66 | .0078 | .428 | .38 |
| 1916 | 57,863,365 | 1.70 | .0069 | .424 | .42 |

*Copper ores produced in the United States, 1906–1916, classified as smelting and concentrating ores, and average yield in copper.*

| Year. | Smelting ores. | | Concentrating ores. | |
|---|---|---|---|---|
| | Quantity. | Yield in copper. | Quantity. | Yield in copper. |
| | *Short tons.* | *Per cent.* | *Short tons.* | *Per cent.* |
| 1906 | 3,278,000 | ..... | 14,722,000 | ..... |
| 1907 | 3,957,500 | 4.05 | 16,295,500 | 1.41 |
| 1908 | 4,665,534 | 4.27 | 17,760,522 | 1.485 |
| 1909 | 5,267,707 | 4.15 | 22,664,911 | 1.47 |
| 1910 | 5,001,394 | 4.14 | 23,495,844 | 1.40 |
| 1911 | 4,355,650 | 4.66 | 25,632,585 | 1.34 |
| 1912 | 5,014,018 | 4.45 | 30,642,396 | 1.26 |
| 1913 | 5,290,310 | 4.22 | 31,046,372 | 1.22 |
| 1914 | 4,597,398 | 4.23 | 30,467,626 | 1.20 |
| 1915 | 5,433,907 | 4.60 | 37,966,553 | 1.26 |
| 1916 | 6,928,010 | 4.72 | 50,935,355 | 1.28 |

The output of copper-bearing ores in 1916 showed a marked increase over that of any preceding year. For the last 11 years there has been a steady increase in the production of these ores except in 1914, when there was a slight decrease. During the 11 years the total output has increased about 220 per cent. Arizona is the largest producer of copper ore, followed in order by Utah, Michigan, Montana, Nevada, New Mexico, California, Tennessee, and Alaska. In the output of smelting ore Arizona is first, followed by Utah, California, Montana, Tennessee, Alaska, and New Mexico. In the output of concentrating ore Arizona is first, followed by Michigan, Utah, Montana, Nevada, New Mexico, and Alaska.

## YIELD OF COPPER FROM ORES.

The average yield of copper from copper ore in 1916 was 1.70 per cent. There was a steady decrease in the average yield of copper ores from about 2.50 per cent in 1906 to 1.60 per cent in 1914, but the yield in 1915 and 1916 has each shown increase. The decrease from 1906 to 1914 may be taken as a general measure of the improvement in metallurgic practice that has made possible the treatment of lower-grade material. The increase in 1915 and 1916 is doubtless due mainly to the increase in the recovery of copper resulting from the introduction of improved methods, notably the flotation process.

Since 1906 the average yield from direct smelting ores has increased from 4.05 per cent to 4.72 per cent; that from concentrating ores has decreased from 1.48 per cent in 1908 to 1.20 per cent in 1914, since which year it has increased to 1.28 per cent, owing to improved metallurgical processes, as already noted.

Of the important copper-producing States, Alaska produced the highest grade of copper ore in 1916, followed in order by California, Montana, Arizona, Tennessee, New Mexico, Nevada, Michigan, and Utah. Of the States producing smelting ore in large quantity, Alaska had the highest yield, followed by Arizona, Nevada, Montana, California, New Mexico, and Tennessee. Of the States producing concentrating ores in large quantity, Alaska had the highest grade, followed by Montana, California, Arizona, New Mexico, Nevada, Michigan, and Utah.

The average recovery of gold and silver from copper ores shows a variation about in proportion to that of copper. In 1906 copper ores averaged 85.6 cents per ton in gold and silver, in 1916 the average yield was 42 cents per ton. Among the principal copper-producing States, California was first in the average yield of gold and silver per ton of ore, followed by Alaska, Montana, Arizona, Nevada, Utah, Tennessee, and New Mexico.

## REVIEW BY STATES.

### SCOPE OF DISCUSSION.

In the following pages a brief statement of the conditions affecting production in the principal copper districts of the country is presented and the tenor of ore from each district is given so far as it does not disclose the production of those individual companies whose figures of output have not already been published in their annual reports or elsewhere. Those who desire more detailed information on the mining operations of the districts are referred to the reports on mine production in the several States, which form other chapters of Mineral Resources, as set forth in the prefatory note.

Figures of metal output, ore reserves, metal content, and recovery in treatment of individual companies given in this report, unless otherwise stated, are quoted from the official reports of the companies.

The report for 1915 contains a map showing the location of the copper-producing districts and the metallurgic plants and also a brief discussion of the geologic occurrence of the ores in the different districts. Copies of the report for 1915 may be obtained on application to the Director of the United States Geological Survey.

### ALASKA.

The production of blister copper from Alaska in 1916 was 113,823,064 pounds, as compared with 70,695,286 pounds in 1915. The mine production of copper in 1916 was 119,854,839 pounds.

Alaska began to produce copper in notable quantity about 1903, and since that time it has been a steady contributor. Its total production of blister copper to the end of 1916 is 323,979,820 pounds. The output in 1916 came from the Ketchikan, Prince William Sound, and Copper River districts.

*Ketchikan district.*—Copper mining in the Ketchikan district was unusually active in 1916. The mines yielded 75,311 tons of ore, from which 3,526,703 pounds of copper were produced. The ores are shipped to the Tacoma smelter.

*Prince William Sound district.*—Copper mining in the Prince William Sound district in 1916 was active, and the output was one of the largest made by this district. The ores of the district were shipped to the Tacoma smelter. The largest producer was the Beatson Bonanza mine, but much ore was taken from the Ellamar mine. Other copper properties were being developed and made small outputs.

There was mined from the Beatson mine, of the Kennecott Copper Corporation, 184,411 tons of ore averaging 2.30 per cent copper. The ore milled during the year amounted to 177,803 tons, averaging

2.12 per cent copper. The concentration was in a ratio of 8.59 into 1. Concentrates amounted to 20,701 tons, averaging 14.29 per cent copper. The average recovery was 78.91 per cent. Direct shipping ore to the amount of 6,608 tons averaging 7.23 per cent copper was produced.

Plans were completed during the year for the enlargement of the concentrating plant from 700 tons to 1,500 tons daily capacity. It is expected that the enlarged plant will be completed in 1917.

*Copper River district.*—The Bonanza and Jumbo mines of the Kennecott Copper Corporation were the largest producers in the Copper River district. The Mother Lode Copper Mines Co., of the Chitina district, also produced in 1916.

During the year there was mined from the Bonanza and Jumbo mines 297,843 tons of ore averaging 18.69 per cent copper, and 229,717 tons of ore milled averaged 8.49 per cent copper. Concentration ratio was 7.67 into 1, with average recovery of 82.27 per cent. Concentrates amounted to 29,949 tons averaging 53.6 per cent. High-grade ore produced amounted to 48,855 tons averaging 67.9 per cent copper, and second-class ore amounting to 19,271 tons averaged 15.6 per cent copper. The ammonia leaching plant was started in the year and treated 62,450 tons of tailings averaging 1.48 per cent copper. There were 703 tons of precipitate produced that averaged 69.9 per cent copper. Plans have been adopted for increasing the leaching plant from 300 tons daily capacity to 700 tons.

## ARIZONA.

In 1916 Arizona produced 694,847,307 pounds of blister copper, compared with 432,467,690 pounds in 1915.

The steady output of copper from Arizona began about 1875, though there had been intermittent production since 1862. Since 1880 the growth of the industry has been steady and rapid, and to the end of 1916 Arizona had a recorded production of 5,767,698,935 pounds of copper, or 24.74 per cent of the total output of the country, thus ranking third among the States. In 1916 Arizona produced 36.04 per cent of the total output. The greater part of the production came from five districts. Eleven copper-smelting plants were operated within the State during the year.

*Bisbee district.*—The Bisbee or Warren district, in southern Cochise County, was the second largest producer in the State in 1916, being surpassed for the first time by the Globe-Miami district. Production in this district began in 1880, and since that time it has been a constant and increasingly important contributor to the output of copper. To the end of 1916 it had produced 2,219,556,000 pounds of copper, or 9.52 per cent of the output of the country. In total output it ranks third and in present output fifth among the copper districts of the country.

*Copper produced in Bisbee district, Ariz., 1906–1916.*

| Year. | Quantity. | Average yield in copper. | Value in gold and silver per ton. | Year. | Quantity. | Average yield in copper | Value in gold and silver per ton. |
|---|---|---|---|---|---|---|---|
| | *Pounds.* | *Per cent.* | | | *Pounds.* | *Per cent.* | |
| 1906 | 131,000,000 | 6+ | ..... | 1912 | 140,000,000 | 5.6 | $1.41 |
| 1907 | 110,000,000 | 6+ | ..... | 1913 | 155,100,000 | 5.6 | 1.16 |
| 1908 | 129,000,000 | 6+ | ..... | 1914 | 151,600,000 | 5.4 | 1.35 |
| 1909 | 130,000,000 | 6+ | ..... | 1915 | 164,600,000 | 5.0 | 1.66 |
| 1910 | 142,500,000 | 5.4 | $1.07 | 1916 | 193,600,000 | 4.9 | 1.51 |
| 1911 | 130,200,000 | 5.9 | 1.42 | | | | |

Most of the ore occurs as irregular replacement bodies in limestone without any definite arrangement, and the cost of prospecting is consequently rather high. The irregular character of the ore deposits and the heavy ground, especially in the oxidized ore bodies, have resulted in relatively high cost of extraction. Recently, however, modifications in the system of mining have resulted in a decrease in the timber used per ton of ore and also in the cost of extraction. The cost of mining will, nevertheless, doubtless remain high compared with the cost in districts where cheaper systems of mining can be safely and economically employed.

In recent years large bodies of disseminated ore have been found in the altered granite porphyry of Sacramento Hill.

Developments during the year resulted in an increase in the ore reserves of the district over those of the previous year.

The production of the Copper Queen Consolidated Mining Co., as summarized in the company's report, is as follows:

*Metals produced by Copper Queen Consolidated Mining Co., 1916.*

**Production of mines.**

| | Ore, dry weight. | Gold. | Silver. | Copper. | Lead. |
|---|---|---|---|---|---|
| | *Short tons.* | *Ounces.* | *Ounces.* | *Pounds.* | *Pounds.* |
| Shipped to Douglas | 853,279 | 22,898 | 809,911 | 98,188,475 | ..... |
| Shipped to El Paso | 23,462 | 1,113 | 275,323 | 647,274 | 9,136,010 |
| Precipitates | 765 | ..... | ..... | 656,249 | ..... |
| Old dump slag | 73,657 | ..... | 5,911 | 3,143,422 | ..... |
| Concentrates shipped | 815 | 19 | 4,991 | 50,302 | 285,552 |
| | 951,978 | 24,030 | 1,096,136 | 102,685,722 | 9,421,562 |

**Production of reduction works.**

| | Ore, dry weight. | Gold. | Silver. | Copper. |
|---|---|---|---|---|
| Copper Queen: | *Short tons.* | *Ounces.* | *Ounces.* | *Pounds.* |
| Ore and precipitates | 831,890 | 23,605 | 742,715 | 91,004,771 |
| Lease ore | 19,406 | 142 | 26,795 | 1,796,140 |
| Concentrates | 399 | 2 | 125 | 41,885 |
| Old dump slag | 75,210 | ..... | ..... | 2,554,423 |
| Burro Mountain Copper Co.: Concentrates | 24,604 | 68 | 18,180 | 6,307,740 |
| Moctezuma Copper Co.: Ore and concentrates | 135,830 | 1,212 | 418,712 | 32,365,093 |
| All other ore | 217,184 | 7,803 | 588,327 | 37,823,828 |
| | 1,304,523 | 32,832 | 1,794,854 | 171,893,880 |

*Metals produced by Copper Queen Consolidated Mining Co., 1911–1916.*

| Year. | Ore. | Copper. | Silver. | Gold. | Lead. | Earnings. | Dividends. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Ounces.* | *Ounces.* | *Pounds.* | | |
| 1911 | 619,132 | 74,499,728 | 1,227,453 | 16,895 | 5,658,930 | $4,155,010 | $5,200,000 |
| 1912 | 786,368 | 88,280,908 | 1,027,130 | 18,028 | 2,953,685 | 6,977,378 | 5,707,351 |
| 1913 | 867,481 | 97,181,725 | 919,138 | 16,213 | 5,701,628 | 6,916,900 | 5,700,000 |
| 1914 | 732,829 | 86,066,143 | 1,036,672 | 15,769 | 8,889,175 | 6,042,001 | 4,500,000 |
| 1915 | 833,107 | 88,551,180 | 943,368 | 18,974 | 9,388,418 | ..... | ..... |
| 1916 | 951,978 | 102,685,722 | 1,096,136 | 24,030 | 9,421,562 | ..... | ..... |

The company reports that more ore was developed during the year than was mined. It is planned to mine the West disseminated ore body in Sacramento Hill by steam shovel methods and a concentration plant for its treatment will have to be constructed.

The production of the Calumet & Arizona Mining Co. was the largest in its history. The following table shows the results of operations in recent years:

*Metals produced by Calumet & Arizona Mining Co., including the Superior & Pittsburgh Co. before the consolidation of the two, 1911–1916.*

| Year. | Company. | Ore smelted. | Copper produced. | Copper recovered. | Gold. | Silver. | Dividends. |
|---|---|---|---|---|---|---|---|
| | | *Short tons.* | *Pounds.* | *Per cent.* | *Ounces.* | *Ounces.* | |
| 1911 | Calumet & Arizona | 231,135 | 21,476,739 | 4.487 | 9,329 | 216,987 | $1,969,059 |
| | Superior & Pittsburgh | 230,620 | 28,469,166 | 6.1859 | 8,785 | 236,960 | 1,739,758 |
| 1912 | Calumet & Arizona | 169,287 | 16,490,229 | 4.34 | 9,066 | 233,092 | 2,542,781 |
| | Superior & Pittsburgh | 318,418 | 36,618,399 | 5.762 | 13,815 | 361,227 | 1,919,733 |
| 1913 | Calumet & Arizona | 111,541 | 52,621,651 | 4.485 | 15,890 | 540,214 | 3,059,208 |
| | Superior & Pittsburgh | 376,568 | | 5.785 | | | |
| 1914 | Calumet & Arizona | 540,468 | 49,992,909 | 4.62 | 19,744 | 573,606 | 1,851,008 |
| 1915 | do | 729,677 | 63,126,931 | 4.33 | 26,212 | 947,129 | 2,006,557 |
| 1916 | do | 845,286 | 70,702,028 | 4.17 | 31,673 | 1,267,734 | 5,777,296 |

At the reduction works at Douglas 1,085,082 tons of ore were treated.

The net cost per pound of refined copper in 1916, after deducting the value of gold and silver, was 9.04 cents. Net income for the year was $11,155,004.81. To the close of 1916 the company has paid dividends to the amount of $30,817,001.93.

The following table shows the results of operations of the Shattuck Arizona Copper Co.:

*Metals produced by Shattuck Arizona Copper Co., 1911–1916.*

| Year. | Copper. | Silver. | Gold. | Lead. | Copper recovered. | Dividends. |
|---|---|---|---|---|---|---|
| | *Pounds.* | *Ounces.* | *Ounces.* | *Pounds.* | *Per cent.* | |
| 1911 [a] | 4,111,000 | ..... | ..... | ..... | ..... | ..... |
| 1912 [b] | 1,253,305 | 21,008 | 13 | ..... | 7.13 | ..... |
| 1912 [c] | 1,746,493 | 15,165 | 16 | ..... | 6.67 | ..... |
| 1913 | 13,219,756 | 236,000 | 2,033 | 1,483,956 | 6.67 | $525,000 |
| 1914 | 10,846,918 | 198,419 | 2,445 | 14,066 | 5.79 | 525,000 |
| 1915 | 11,154,211 | 201,869 | 3,151 | 2,345,342 | 5.89 | 875,000 |
| 1916 | 18,161,763 | 314,918 | 4,721 | 3,413,445 | 5.38 | 1,662,500 |

[a] Year ending August, 1911.
[b] Year ending August, 1912.
[c] Aug. 1 to Dec. 31, 1912, inclusive.

*Mine and smelter production of Shattuck Arizona Copper Co., 1916.*

| | Copper ore. | | Lead ore. | |
|---|---|---|---|---|
| | Wet. | Dry. | Wet. | Dry. |
| Tons ore stoped | 173,321 | 158,896 | 13,613 | 10,162 |
| Tons ore developed | 8,824 | 8,146 | 928 | 865 |
| Tons second-class ore, etc. | 1,393 | 1,225 | ..... | ..... |
| Tons ore mined | 183,538 | 168,257 | 11,541 | 11,027 |
| Tons ore shipped | 183,627 | 168,331 | 11,636 | 11,116 |
| Tons ore smelted | 183,968 | 168,643 | 10,531 | 10,069 |

| | | |
|---|---|---|
| Copper recovered | pounds.. | 18,161,763 |
| Gold recovered | ounces.. | 4,721 |
| Silver recovered | do.... | 314,918 |
| Lead recovered | pounds.. | 3,413,445 |

**Recoveries per dry ton.**

| | | Copper. | Lead. |
|---|---|---|---|
| Bullion | pounds.. | 107.69 | 339 |
| Gold | ounces.. | .028 | .165 |
| Silver | do.... | 1.867 | 4.759 |

**Cost per pound of refined copper.**

| | | |
|---|---|---|
| Gross operating cost | cents.. | 11.316 |
| Less operating credits | do.... | 2.600 |
| Net operating cost | | 8.716 |

The company reports important developments of ore during the year.

*Globe-Miami district.*—Production of copper began in the Globe district in 1881; the camp was well known as a silver producer before that date. For several years the production was intermittent, but since 1888, and especially since 1898, when the railroad reached the camp, the district has ranked among the large copper producers of the country. To the end of 1916 it has produced 903,200,000 pounds of copper, or 3.87 per cent of the output of the country since 1845. In total production the district ranks sixth in the country and third in the State; for 1916 it ranked fourth in the country and first in the State. The Miami part of the district made its first notable output in 1911.

*Copper produced in Globe-Miami district, Ariz., 1906–1916.*

| Year. | Copper. | Yield of ore in copper. | Year. | Copper. | Yield of ore in copper. |
|---|---|---|---|---|---|
| | *Pounds.* | *Per cent.* | | *Pounds.* | *Per cent.* |
| 1906 | 27,000,000 | 3.4 | 1912 | 61,600,000 | 2.21 |
| 1907 | 35,000,000 | 4 | 1913 | 71,000,000 | 2.38 |
| 1908 | 36,000,000 | 4.5 | 1914 | 72,000,000 | 2.41 |
| 1909 | 33,000,000 | 4.43 | 1915 | 98,500,000 | 2 |
| 1910 | 27,600,000 | 5 | 1916 | 220,000,000 | 1.43 |
| 1911 | 44,600,000 | 3.35 | | | |

*Ore produced by Old Dominion Copper Mining & Smelting Co., 1916.*

| | Quantity (short tons). | Percentage of copper. |
|---|---|---|
| Smelting ore | 98,761 | 7.08 |
| Concentrating ore | 48,909 | 3.72 |
| Silica ore | 4,389 | 3.89 |
| | 152,059 | 5.88 |

*Metals produced by Old Dominion Copper Mining & Smelting Co., 1911–1916.*

| Year. | Ore. | Copper. | Gold. | Silver. | Average yield in copper. | Cost per pound of copper. | Dividends. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Ounces.* | *Ounces.* | *Per cent.* | *Cents.* | |
| 1911 | 174,246 | 19,195,181 | 936 | 42,050 | 5.84 | 9.5 | $486,000 |
| 1912 | 201,181 | 16,533,993 | 583 | 42,750 | 4.67 | 10.34 | 729,000 |
| 1913 | 169,961 | 18,945,153 | 419 | 51,316 | 5.88 | 9.7 | 810,000 |
| 1914 | 129,813 | 17,816,284 | 603 | 33,311 | 7.44 | 8.22 | 445,500 |
| 1915 | 115,459 | 13,771,681 | 620 | 40,632 | 6.56 | 8.90 | 1,053,000 |
| 1916 | 152,059 | 17,654,643 | 1,240 | 60,688 | 5.88 | 11.69 | 1,944,000 |

*Ore produced by United Globe mines, 1916.*

| | Quantity (short tons). | Percentage of copper. |
|---|---|---|
| Smelting oxide | 15,378.602 | 7.16 |
| Concentrating ore | 187,279.690 | 3.28 |
| Silica | 3,504.963 | 5.45 |
| | 206,163.255 | 3.60 |

*Metals produced by United Globe mines, 1911–1916.*

| Year. | Ore. | Copper. | Silver. | Gold. | Yield in copper. | Dividends. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Ounces.* | *Ounces.* | *Per cent.* | |
| 1911 | 110,578 | 8,525,433 | 111,459 | 876 | 3.85 | ..... |
| 1912 | 188,254 | 12,252,073 | 124,362 | 789 | 3.25 | $460,000 |
| 1913 | 167,919 | 11,348,100 | 119,588 | 1,537 | 3.38 | 690,000 |
| 1914 | 155,205 | 11,086,674 | 91,582 | 1,580 | 3.57 | 425,500 |
| 1915 | 141,240 | 11,536,021 | 105,109 | 1,508 | 4.08 | 621,000 |
| 1916 | 206,163 | 14,852,399 | 128,066 | 1,543 | 3.60 | 1,679,000 |

Dividends paid by the Old Dominion Co. to December 31, 1916, amount to $8,424,000.

Total dividends paid by the United Globe mines to the end of 1916 amount to $4,255,000.

The smelters of the Old Dominion Co. at Globe and of the International Smelting & Refining Co. at Miami were operated throughout the year.

The district is served by the Arizona Eastern Railroad.

The Arizona Commercial Mining Co. produced 48,890 tons of ore averaging 5.028 per cent copper. The metal output was 4,178,474 pounds of copper, 21,163 ounces of silver, and 305 ounces of gold. The net earnings for the year were $548,768. A dividend of $132,500 was paid during the year.

The following tables show the operations of the Miami Copper Co.:

*Copper produced by Miami Copper Co., 1911–1916.*

| Year. | Ore. | Copper content. | Mill extraction. | Refined copper. | Cost of copper per pound. | Dividends. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Per cent.* | *Pounds.* | *Cents.* | |
| 1911 | 445,036 | 2.48 | 73.37 | 15,385,783 | 9.103 | ..... |
| 1912 | 1,040,744 | 2.393 | 69.39 | 32,832,609 | 9.5884 | $1,100,112 |
| 1913 | 1,058,784 | 2.30 | 71.06 | 32,867,666 | 10.6086 | 1,491,989 |
| 1914 | 1,096,633 | 2.28 | 69.93 | 33,296,010 | 9.2045 | 1,120,375 |
| 1915 | 1,348,122 | 2.17 | 75.17 | 41,832,059 | 8.76 | 1,681,004 |
| 1916 | 1,842,017 | 2.07 | 73.88 | 53,518,331 | 9.52 | 4,295,905 |

*Milling operations of Miami Copper Co., 1916.*

| | | |
|---|---|---|
| Ore milled | short tons.. | 1,348,122 |
| Copper in ore | per cent.. | 2.070 |
| Concentrates produced | short tons.. | 66,289 |
| Copper in concentrates | per cent.. | 42.492 |
| Copper in concentrates | pounds.. | 56,335,103 |
| Copper recovered per ton of ore | do.... | 30.58 |
| Mill extraction | per cent.. | 73.88 |

*Cost of copper in concentrates f. o. b. cars at Miami, Ariz., 1916.*

| | Per ton of ore. | Per pound of copper. |
|---|---|---|
| Mining | $1.118834 | $0.0385085 |
| Milling | .589143 | .0202774 |
| General | .229440 | .0078970 |
| | 1.937417 | .0666829 |

*Ore reserves of Miami Copper Co., Jan. 1, 1917.*

| | Quantity (short tons). | Percentage of copper. |
|---|---|---|
| High-grade sulphide ore | 16,400,000 | 2.40 |
| Low-grade sulphide ore | 28,000,000 | 1.06 |
| Mixed sulphide and oxide ore | 6,000,000 | 2.00 |
| | 50,400,000 | ..... |

The last units of the Inspiration mill, as originally designed, were placed in operation in February, 1916. During the year two additional units were in process of construction to be completed in 1917. It is expected that the 20 sections will have a capacity of 18,000 tons daily.

The total copper produced was 120,772,637 pounds at an operating cost of 8.673 cents per pound.

The following table shows the cost of the several operations:

*Cost of copper derived from concentrating ores of the Inspiration Consolidated Copper Co., 1916.*

| | Cost per pound of copper. | Cost per ton of ore. |
|---|---|---|
| | Cents. | |
| Mining | 2.702 | $0.60708 |
| Coarse crushing | .125 | .02798 |
| Ore hauling | .069 | .01540 |
| Concentrating and royalty | 2.243 | .50385 |
| Concentrate hauling | .006 | .00145 |
| Smelting, freight, refining, marketing, etc | 3.528 | .79269 |
| | 8.673 | 1.94845 |

*Mill statistics, Inspiration Consolidated Copper Co., 1916.*

| | | | |
|---|---|---|---|
| Total ore milled | dry tons | | 5,316,350.1 |
| Ore milled per day | do | | 14,850.1 |
| Average number of sections running | | | 16.54 |
| Average output per section | tons | | 897.8 |
| Assay mill feed | per cent of copper | | 1.548 |
| Screen analysis of feed (on 48 mesh) | per cent | | 3.3 |
| Copper in feed, oxidized | do | | .335 |
| Copper assay of general tailings | do | | .397 |
| Copper in general tailings, oxidized | do | | .283 |
| Copper in general concentrates, smelter assay | do | | 30.688 |
| Copper in flotation concentrates | do | | 37.50 |
| Copper in table concentrates | do | | 11.23 |
| Moisture in general concentrates | do | | 17.27 |
| Concentrates produced per ton of ore | tons | | .0377 |
| Recovery of copper calculated from (smelter assays): | | | |
| Assays only | per cent | | 75.33 |
| Assays and weights of concentrates and feed | do | | 74.86 |
| Assays and weights of concentrates and tails | do | | 75.18 |
| Assays and weights of feed and tails | do | | 75.29 |
| Recovery of copper sulphides | do | | 90.95 |
| Water used per ton of ore (February, 1917, figures): | | | |
| Reclaimed in tanks at foot of mill | gallons | 354 | |
| Reclaimed from ponds | do | 528 | |
| New water from Kiser pump station | do | 226 | |
| | | | 1,108 |
| Steel balls consumed per ton of ore milled | | | 1.76 |
| Flotation oil consumed per ton of ore milled: | | | |
| Coal tar | pounds | 1.20 | |
| Other oils | do | .087 | |
| | | | 1.287 |

No attempt was made to develop additional ore. At the end of the year reserves were given as 91,789,120 tons, of which about 20,000,000 tons are to be classified as oxidized ores, as against 97,143,000 at the end of 1915.

Net profits for the year were $20,629,489. Dividends amounting to $8,548,050.75 were paid.

*Morenci-Metcalf district.*—The Morenci-Metcalf district is one of the oldest copper-producing districts in the State. Production began here in 1873, and since 1880 the district has been a large contributor to the copper output of the country. To the end of 1916 it had produced 1,297,196,000 pounds of copper, or 5.56 per cent of the output

of the country since 1845. In total production it ranks fifth among the copper districts of the country. In the output for 1916 it ranks tenth.

The strike which began September 12, 1915, was not settled till January 20, 1916, so that production in 1916 covered a period of about 11 months.

*Copper produced in Morenci-Metcalf district, 1906–1916.*

| Year. | Quantity. | Average yield of copper from ore. | Year. | Quantity. | Average yield of copper from ore. |
|---|---|---|---|---|---|
| | *Pounds.* | *Per cent.* | | *Pounds.* | *Per cent.* |
| 1906 | 56,000,000 | ..... | 1911 | 71,500,000 | 2.29 |
| 1907 | 63,000,000 | ..... | 1912 | 79,900,000 | 2.21 |
| 1908 | 77,000,000 | ..... | 1913 | 70,100,000 | 2.00 |
| 1909 | 72,000,000 | 2.29 | 1914 | 66,000,000 | 1.95 |
| 1910 | 73,154,000 | 2.35 | 1915 | 51,096,000 | 2.01 |
| | | | 1916 | 75,976,831 | 1.89 |

In 1916 of the mine production of copper 58,733,000 pounds was derived from concentrating ores and 17,098,000 pounds from smelting ores. The mines of the district produced 1,791,458 tons of concentrating ores and 220,404 tons of smelting ore.

The ores in general carry little gold and silver, and, as much of the copper is of sufficient purity for commercial purposes, it is not refined electrolytically, and consequently the precious-metal content is not separated from the copper.

*Copper produced by Detroit Copper Co., 1911–1916.*

| Year. | Ore treated (short tons). | Copper produced. | | Dividends. |
|---|---|---|---|---|
| | | Quantity (pounds). | Per centage. | |
| 1911 | 517,087 | 22,704,398 | 2.29 | $800,000 |
| 1912 | 520,272 | 24,802,789 | 2.38 | 1,464,610 |
| 1913 | 537,324 | 22,255,130 | 2.07 | 780,000 |
| 1914 | 477,581 | 20,272,607 | 2.12 | 280,000 |
| 1915 | 376,604 | 15,333,976 | 2.03 | ..... |
| 1916 | 474,808 | 17,541,258 | 1.85 | ..... |

*Copper produced by Detroit Copper Co., 1916, by kinds of ore.*

| | Ore treated. | Copper produced. | Assay of original ore. | Yield. |
|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Per cent.* | *Per cent.* |
| Concentrating ore | 454,027 | 14,711,658 | 2.39 | 1.62 |
| Smelting ore | 11,325 | 2,031,340 | 9.40 | 8.97 |
| Old slag and tailings | 1,659 | 114,940 | 3.66 | 3.46 |
| Siliceous ore to converters | 7,797 | 681,920 | 4.58 | 4.37 |
| | 474,808 | 17,539,858 | 2.60 | 1.85 |

*Result of concentration operations by the Detroit Copper Co., 1916.*

| | Quantity (short tons). | Average assay (per cent copper). |
|---|---|---|
| Ore concentrated | 451,394.8 | 2.337 |
| Concentrates produced | 63,595.3 | 12.074 |
| Tailings produced | | .729 |

| | | |
|---|---|---|
| Saving | per cent.. | 71.25 |
| Ratio of concentration | | 7.098 |
| Proportion of actual running time to total time | per cent.. | 87.69 |

*Result of smelting and converting operations of Detroit Copper Co., 1916.*

| | | |
|---|---|---|
| Ores, concentrates, and flux smelted | short tons.. | 99,005.2 |
| New copper-bearing material smelted | do.... | 84,669.0 |
| Copper contained to account for | do.... | 9,212.31 |
| Copper in bullion produced | do.... | 8,770.629 |
| Metallurgic loss | do.... | 441.681 |
| Copper lost in slag | do.... | 178.111 |
| Unaccounted for loss | do.... | 263.570 |
| Recovery made | per cent.. | 95.21 |
| Copper in matte | do.... | 34.43 |
| Copper in slag | do.... | .27 |
| Coke to total charge | do.... | 12.43 |
| Limestone to total charge | do.... | 10.17 |

*Copper produced by Arizona Copper Co., 1911–1916.*

| Year ending Sept. 30. | Ore treated. | Copper produced. | Average yield. | Year ending Sept. 30. | Ore treated. | Copper produced. | Average yield. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Per cent.* | | *Short tons.* | *Pounds.* | *Per cent.* |
| 1911 | 744,746 | 34,584,000 | 2.32 | 1914 | 1,079,950 | 38,756,000 | 1.808 |
| 1912 | 927,116 | 38,132,000 | 2.057 | 1915 | 968,566 | 37,330,000 | 1.961 |
| 1913 | 936,903 | 34,226,000 | 1.938 | 1916 | 905,486 | 34,100,000 | 1.803 |

*Metals produced by Shannon Copper Co., 1911–1916.*

| Year. | Ore. treated. | Copper produced. | Average yield in copper. | Gold. | Silver. | Dividends. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Per cent.* | *Ounces.* | *Ounces.* | |
| Year ending August, 1911 | 263,975 | 15,168,102 | 2.845 | 1,690 | 91,955 | ..... |
| Year ending August, 1912 | 285,210 | 16,406,336 | 2.876 | 2,615 | 170,690 | $150,000 |
| August to December 31, 1912 | 95,235 | 5,149,805 | 2.704 | 1,012 | 54,394 | ..... |
| 1913 | 434,307 | 18,793,724 | 2.163 | 3,412 | 169,197 | 150,000 |
| 1914 | 193,297 | 9,003,169 | 2.33 | 1,295 | 60,603 | ..... |
| 1915 | ..... | 6,017,642 | ..... | 690 | 35,449 | ..... |
| 1916 | ..... | 9,364,968 | ..... | 1,327 | 62,935 | 150,000 |

The company had under construction a 150-ton leaching plant which will be completed in 1917.

*Jerome district.*—The production of copper in the Jerome district began about 1883, though it had yielded gold and silver prior to that time. Since 1888 it has been a steady and important producer. To the end of 1916 it has produced 855,440,000 pounds of copper, or 3.67 per cent of the total output of the country since 1845. In total output it stands seventh among the copper districts of the country, and in output for 1916 it ranks seventh.

*Copper produced in Jerome district, Ariz., 1911–16.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 38,500,000 | 1910 | 38,600,000 | 1914 | 30,000,000 |
| 1907 | 33,000,000 | 1911 | 33,200,000 | 1915 | 53,260,000 |
| 1908 | 36,000,000 | 1912 | 31,680,000 | 1916 | 102,000,000 |
| 1909 | 36,700,000 | 1913 | 35,300,000 | | |

The United Verde Copper Co. was the largest producer in the district.

The United Verde Extension Mining Co. shipped 80,159 tons of ore containing 2,570 ounces of gold, 128,467 ounces of silver, and 36,402,972 pounds of copper, an average of 0.032 ounce gold, 1.62 ounces silver, and 454.1 pounds copper per ton.

Net earnings for the year amounted to $6,938,100.56. Dividends were paid to the amount of $1,050,000.

Prospecting was active in the district during the year.

*Ray or Mineral Creek district.*—Notable production in the Ray or Mineral Creek district began in 1911, and the total production to the end of 1916 has been 296,678,000 pounds. The Ray Consolidated Mining Co. has been the only important producer in the district.

*Copper produced by Ray Consolidated Mining Co., 1911–1916.*

| Year. | Ore milled. | Copper content. | Mill recovery. | Refined copper. | Cost per pound. | Dividends. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Per cent.* | *Pounds.* | *Cents.* | |
| 1911 | 681,519 | 1.83 | 63.1 | 14,935,047 | 10.75 | ..... |
| 1912 | 1,565,375 | 1.677 | 68.278 | 34,674,275 | 9.828 | ..... |
| 1913 | 2,365,296 | 1.719 | 66.09 | 82,341,029 | 9.783 | $1,631,504 |
| 1914 | 2,427,700 | 1.76 | 67.88 | 57,004,281 | 8.839 | 1,089,322 |
| 1915 | 2,848,969 | 1.673 | 64.11 | 60,338,936 | 9.497 | 1,872,319 |
| 1916 | 3,332,340 | 1.607 | 70.20 | 74,983,540 | 10.267 | 4,337,955 |

During the year there was milled 3,332,340 tons of ore having an average copper content of 1.607 per cent. The average recovery was 70.20 per cent.

Ore reserves at the end of the year were estimated at 93,373,226 tons, averaging 2.03 per cent copper. The concentrates are treated at the Hayden plant of the American Smelting & Refining Co.

Net profits for the year amounted to $12,084,165.77.

*Ajo district.*—The Ajo district is in Pima County, about 45 miles from Gila Bend, which is on the Southern Pacific Railroad and with which it is connected by the Tucson, Cornelia & Gila Bend Railroad. Daily service on this road was begun February 20, 1916, from Gila Bend to Cornelia.

The property of the New Cornelia Copper Co. has been under development by the same interests that control the Calumet & Arizona Mining Co. The company estimates the ore as follows: Carbonate ore, 11,954,400 tons, averaging 1.54 per cent copper; sulphide ore, 28,303,600 tons, averaging 1.50 per cent copper; total, 40,258,000 tons, averaging 1.51 per cent copper. Of this, 11,954,400 tons of carbonate ore and 20,526,800 tons of sulphide ore are available for steam-shovel mining.

Construction of the 5,000-ton leaching plant for the treatment of the ores was in progress during 1916 and the plant began producing

copper June 8, 1917. Results of operations of the 40-ton experimental plant were as follows:

*Results of experimental plant of New Cornelia Copper Co., 1916.*

| | | |
|---|---|---|
| Average heads | per cent.. | 1.313 |
| Average tails | do.... | .271 |
| Extraction | do.... | 79.36 |
| Average per kilowatt hour | pounds.. | 0.88 |

The operations of the experimental plant and the ore shipped to Douglas yielded 494,650 pounds of copper and 231 ounces of silver.

*Turquoise district.*—Shipments of copper from the Turquoise district during the year amounted to about 3,250,000 pounds, as compared with 2,048,000 pounds in 1915.

*Silverbell district.*—The Silverbell district in Pima County produced about 3,960,000 pounds of copper in 1916, the largest output in several years. The largest producer was the American Smelting & Refining Co., which is operating the smelter at Sasco that has been closed since 1910. Noteworthy copper production in the district began in 1904, though it had produced some silver and a little copper before that date. To the end of 1916 the district has produced about 45,760,000 pounds of copper.

*Pioneer district.*—The Pioneer district, Pinal County, produced 9,145,000 pounds of copper in 1916, as compared with 6,399,000 pounds in 1915.

The Magma Copper Co., of the Pioneer district, produced 8,473,580 pounds of copper in 1916, at an average cost of 10.803 cents a pound, the operating profits being $1,023,129.

Dividends were paid to the amount of $480,000.

*Ore mined and treated and milling results of the Magma Copper Co., 1916.*

| | Ore. | Copper. | Silver. | Gold. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Ounces.* | | *Per cent.* | *Per cent.* |
| Mined | 82,333 | 5.717 | 6.40 | ..... | ..... | ..... |
| From dump | 1,410 | 4.50 | 5.00 | ..... | ..... | ..... |
| Total treated | 83,743 | 5.696 | 6.376 | ..... | ..... | ..... |
| Crude sorted | 9,126 | 16.756 | 18.802 | $1.76 | ..... | ..... |
| Mill heads | 74,617 | 4.344 | 4.854 | ..... | ..... | ..... |
| Concentrates produced | 20,855 | 12.920 | 14.251 | 2.17 | ..... | ..... |
| Other products: | | | | | | |
| Carbonate ore | 3,450 | 7.936 | 5.611 | 1.10 | ..... | ..... |
| Lead concentrates | 183 | 1.070 | 24.350 | .43 | 15.10 | 16.97 |
| Zinc concentrates | 429 | ..... | 32.440 | .25 | 7.00 | 38.27 |

The average assay of mill tailings was 0.7158 per cent copper (of which 0.225 per cent copper was oxidized), and 0.84 ounce of silver per ton. Sorting and milling the copper sulphide ores resulted in an extraction of 83.13 per cent of total copper in the mill heads and 88.54 per cent of the total copper in the mine run ore treated by hand sorting and milling.

*Estimated ore reserves of Magma Copper Co. at end of 1916.*

| | Ore. | Gold per ton. | Silver per ton. | Copper. | Lead. | Zinc. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Ounces.* | *Ounces.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Reasonably assured copper sulphide ore | 125,000 | 0.03 | 6.50 | 6.25 | ..... | ..... |
| Reasonably assured lead-zinc ore | 20,000 | ..... | 12.0 | ..... | 2.0 | 13.5 |
| Probable silver sulphide ore | 7,500 | .05 | 30.0 | 0.4 | 2.2 | 6.1 |

Other districts that made important production in 1916 are the Cochise district, Cochise County, 6,204,000 pounds; the Banner district, Gila County, 5,041,000 pounds; the Bentley district, Mohave County, 1,064,000 pounds; the Helvetia and Pima districts, Pima County, 1,958,000 and 6,683,000 pounds, respectively; the Patagonia and Big Bug districts, Santa Cruz County, 1,244,000 and 3,612,000 pounds, respectively; and the Copper Basin, Peck, and Planet districts, Yuma County, 1,225,000, 1,618,000, and 3,929,000 pounds, respectively.

## CALIFORNIA.

In 1916 California produced 43,400,876 pounds of blister copper, compared with 37,658,444 pounds in 1915.

California was among the earliest of the Western States to make a considerable output of copper. Production began in the "foothill" belt about 1862, and for several years California was second only to Michigan in output of copper. Later, however, the industry declined, and California did not again attain high rank as a copper producer until 1897, when production from the Shasta County district began. Since that time the State's output has been steady and large. The production for the early years has been ascertained from the best sources available, and when to this output the known production since 1882 is added it is found that to the end of 1916 California has produced about 655,822,837 pounds of copper, or 2.81 per cent of the output of the country since 1845. In 1916 the output was 2.25 per cent of the total production of the United States. In total output the State ranks fifth among the copper producers of the country, and for 1916 it ranked eighth. Three smelting plants in the State treated copper ores in 1916.

Most of the copper has come from two districts, though numerous other districts have made production, especially in the last few years, and copper minerals are widely distributed over the State. The largest producer has been the Shasta County district.

*Shasta County district.*—The Shasta County copper belt lies in the Klamath Mountains, at the head of the Sacramento Valley, a few miles north of Redding. Sacramento River crosses the belt, separating it into an eastern and a western portion. The eastern portion contains the Bully Hill and Afterthought districts and the western the Iron Mountain and Little Backbone districts. Placer mining was carried on in the county in the early days of mining in the State, and later considerable silver was produced from the gossan outcrop of the copper deposits. Copper minerals had been long known in the county, but not until 1897, when the Mountain Copper Co. (Ltd.) began production at Iron Mountain, did it become an important contributor of copper.

*Copper produced in Shasta County district, Cal., 1906–1916.*

| Year. | Quantity (pounds). | Average yield of copper (per ct.). | Gold and silver per ton. | Year. | Quantity (pounds). | Average yield of copper (per ct.). | Gold and silver per ton. |
|---|---|---|---|---|---|---|---|
| 1906 | 21,000,000 | 3.6 | $3.75 | 1912 | 26,000,000 | 3.58 | $1.84 |
| 1907 | 28,000,000 | 3.0 | 2.70 | 1913 | 26,800,000 | 3.50 | 1.76 |
| 1908 | 32,000,000 | 3.2 | 2.85 | 1914 | 25,100,000 | 3.56 | 1.70 |
| 1909 | 48,000,000 | 3.4 | 2.02 | 1915 | 30,500,000 | 3.29 | 2.09 |
| 1910 | 36,000,000 | 3.0 | 2.14 | 1916 | 39,700,000 | 2.62 | 2.50 |
| 1911 | 29,900,000 | 3.7 | 1.80 | | | | |

The total production to the end of 1916 has been about 514,000,000 pounds, or 2.20 per cent of the total output of the country. In 1916 the district produced 1.98 per cent of the total output. In total output the district ranks ninth and in the production for 1916 it was twelfth among the copper districts of the country.

The principal producing companies in 1916 were the Mountain Copper Co., Mammoth Copper Co., and Balaklala Copper Co. The ores of the Mammoth Co. were smelted at its plant at Kennett, and the Mountain Co.'s ores were smelted at its plant at Martinez, on San Francisco Bay. The Balaklala ores were shipped to the Mammoth plant.

The Mammoth Copper Mining Co. produced 233,848 tons of copper ore and 10,597 tons of zinc ore. The zinc ore was sorted and shipped to the Central States for treatment. Ore of good grade was developed during the year but not sufficient to replace that extracted. A tunnel is being driven to develop the area in sec. 29, from which rich ore lenses have been mined.

The Stowell mine was equipped for extraction of ore. An aerial tramway was constructed connecting the mine with the Balaklala tramway. Shipments of ore to the Mammoth smelter were begun in October and were maintained at about 175 tons per day.

The Friday Lowden tunnel, which is being driven to cut the Mammoth ore zone, had attained a length of nearly 4,000 feet at the close of the year. During the year construction was begun on a plant for the treatment of bag-house dust which has been accumulating for several years. The main purpose of the plant is the electrolytic recovery of the zinc, but several by-products will also be obtained.

Ores were shipped from the Balaklala mine to the Mammoth smelter.

The Mountain Copper Co. treated 162,076 tons of ore and concentrates, derived as follows: Iron Mountain mine, 15,731 tons; No. 8 mine, 60,671 tons of ore and 8,186 tons of concentrates; Hornet mine, 76,151 tons; purchased ore, 1,337 tons. The output of copper was 4,525 tons. The ore reserves at the end of the year were estimated as follows: Some blocks of ore remaining in the old mine were extracted and some ore was sorted from the old filling. It is planned to attempt the development of a method for treating the old fills, which are believed to contain 2½ to 3 per cent copper. In the No. 8 and Complex mines the developed ore reserves showed a considerable decrease during the year, and the quantity of probable ore is slightly smaller. Developed ore, averaging 2.9 per cent cop-

per, is estimated at 116,600 tons and probable ore at 85,000 tons. It is estimated that the Hornet mine contains 145,000 tons, which will be extracted through the present haulage tunnel. A lower tunnel, through which the lower portion of the ore body will be extracted, is being driven.

As in recent years, there was little production from the Bully Hill and Afterthought districts, owing to difficulties arising from the smelter fumes.

Electric power is used almost exclusively at both mines and reduction plants.

The Shasta County belt is served by the Southern Pacific Railroad, which has short branches extending to the smelters. The Iron Mountain district is connected with the main line by a narrow-gage railroad operated by the Mountain Copper Co., and the mines of the Mammoth Co. are connected with the smelter by a combined electric railroad, gravity tram, and steam railroad. The ores of the Balaklala and Trinity mines are delivered to the railroad over a cable tramway. The Bully Hill district is served by a standard-gage branch of the Southern Pacific Railroad. The nearest railroad point to the Afterthought district is Bellavista, on the Anderson & Bellavista Railroad, at a distance of about 15 miles.

*"Foothill" district.*—The "foothill" belt is a rather extensive area of copper deposits which has its best development in Calaveras County. This belt furnished practically the entire copper production from California in the sixties. Subsequent to that period the district was inactive for many years, but from 1887 to 1892 the mines again made some production. The present period of activity began about 1901, and for some years the district has made considerable contributions to the copper output of the State.

There is no accurate record of the output of this district in the early days, but from the records of the production of the State it is estimated that to the end of 1916 it has yielded approximately 135,860,000 pounds of copper.

*Copper produced in "foothill" district, Cal., 1907–1916.*

| Year. | Quantity. | Average yield. | Year. | Quantity. | Average yield. |
|---|---|---|---|---|---|
| | *Pounds.* | *Per cent.* | | *Pounds.* | *Per cent.* |
| 1907 | 4,500,000 | 5 + | 1912 | 6,000,000 | 5.1 |
| 1908 | 4,500,000 | 4 | 1913 | 5,800,000 | 4.5 |
| 1909 | 5,400,000 | 4.6 | 1914 | 4,400,000 | 5.0 |
| 1910 | 8,000,000 | 5.2 | 1915 | 3,700,000 | 5.44 |
| 1911 | 5,500,000 | 4.7 | 1916 | 6,460,000 | 3.07 |

In total output the district ranks thirteenth and in production for 1916 it ranked nineteenth among the copper districts of the country.

*Plumas County.*—In 1916 Plumas County produced 5,150,000 pounds of copper. The principal production was by the Engels Copper Mining Co. and the Walker Mining Co.

*Other counties.*—San Bernardino County produced 1,525,000 pounds in 1916, and Placer and other counties made smaller productions.

## COLORADO.

In 1916 Colorado produced 9,536,193 pounds of blister copper compared with 7,272,178 pounds in 1915. Although the State has no important producing district in which copper is the principal metal, yet it ranked tenth among the copper-producing States in 1916. The total recorded output for the State from the beginning of the industry has been 257,190,893 pounds, or 1.10 per cent of the total for the United States since 1845.

The copper has been derived mainly from the treatment of mixed ores in which copper was a minor constituent, including lead-silver ores and pyritic ores rich in gold and silver. In 1916 the largest production came from Lake County and from San Juan, Ouray, San Miguel, Clear Creek, Chaffee, Dolores, Gilpin, and Fremont counties. Leadville and the San Juan-Ouray region have been the greatest producers of copper. Much of the output is recovered as matte in lead furnaces.

## IDAHO.

During 1916 Idaho produced 7,248,794 pounds of blister copper, compared with 6,217,728 pounds in 1915. The State has made a small and irregular output of copper since 1884, but only since 1903 has it been a steady producer. To the end of 1916 it had a recorded output of 94,307,202 pounds.

*Coeur d'Alene region.*—The Coeur d'Alene region has been the most productive copper area in the State, though it is not the most productive at the present time. Complete figures for the copper output of the district are not on record, but the total production has been approximately 60,900,000 pounds. The Snowstorm mine has been the largest copper producer in the district.

*Alder Creek district.*—There has been intermittent production from the Alder Creek or Mackay district since 1900. In 1916 the mines of the district produced 5,499,000 pounds of copper, the largest producer was the Empire Copper Co.

There are other districts in Idaho, notably that of the Seven Devils region, which contain copper deposits, but owing to lack of transportation facilities they have made but small production.

## MICHIGAN.

The production of refined copper in Michigan in 1916 was 269,794,531 pounds, compared with 238,956,410 pounds in 1915. This output marked a high record for the Lake district.

The mining of copper in Michigan antedates the earliest visits of European explorers to the region. The production on a commercial scale, however, dates from 1845, and since that time the State has been a steady producer and an important factor in the copper industry of the world. To the end of 1916 Michigan has produced 6,029,777,767 pounds of copper, or 25.87 per cent of the output from the United States since 1845. For many years subsequent to

1845 Michigan was the most important copper-producing State, and in total output it is second only to Montana. The entire output comes from the Keweenaw or Lake Superior district.

Although the district has been an active producer for 70 years, many of the older mines still have large reserves of ore, new mines are being opened, and much territory remains to be prospected. Moreover, large quantities of the mill tailings produced when milling methods were less efficient than at present are being re-treated at a profit.

The Lake Superior region is unique in being the only district in which a large output is derived from native copper.

*Copper ore produced in Lake Superior district, Mich., 1906–1916.*

| Year. | Quantity. | Yield of copper. | Year. | Quantity. | Yield of copper. |
|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | | *Short tons.* | *Per cent.* |
| 1906 | 8,904,127 | 1.26 | 1912 | 11,411,941 | 0.96 |
| 1907 | 9,892,214 | 1.1 | 1913 | 7,016,370 | .97 |
| 1908 | 10,531,271 | 1.06 | 1914 | 9,269,413 | .89 |
| 1909 | 11,429,394 | 1.02 | 1915 | 12,334,700 | 1.07 |
| 1910 | 10,869,561 | 1.02 | 1916 | 12,364,114 | 1.08 |
| 1911 | 10,978,827 | 1.00 | | | |

The statistics in the following tables are compiled from the annual reports to the stockholders of the individual companies:

*Ore milled and copper derived therefrom by Michigan copper companies in 1915 and 1916, compiled from the annual reports of the producing companies.*

| Company. | 1915 | | 1916 | |
|---|---|---|---|---|
| | Quantity. | Yield per ton. | Quantity. | Yield per ton. |
| | *Short tons.* | *Pounds.* | *Short tons.* | *Pounds.* |
| Ahmeek | 948,874 | 23.0 | 1,164,010 | 20.7 |
| Alloues | 534,705 | 18.78 | 566,960 | 18.02 |
| Baltic | 378,443 | 31.79 | 369,287 | 33.65 |
| Calumet & Hecla | 1,739,984 | 29.74 | 1,727,794 | 29.97 |
| Centennial | 150,191 | 15.63 | 150,617 | 15.72 |
| Champion | 923,743 | 36.17 | 936,656 | 35.87 |
| Franklin | 122,018 | ..... | 267,286 | ..... |
| Hancock | ..... | ..... | 203,112 | ..... |
| Houghton | 14,657 | 10.69 | 19,444 | 10.55 |
| Isle Royale | 680,270 | 13.7 | 925,419 | 13.4 |
| Keweenaw | ..... | ..... | 6,915 | 9.96 |
| La Salle | 80,959 | 9.67 | 144,829 | 9.53 |
| Mass | 323,335 | 14.35 | 287,900 | 16.51 |
| Mohawk | 829,789 | 19.15 | 664,547 | 20.82 |
| Osceola | 1,361,089 | 14.5 | 1,284,681 | 15.2 |
| Quincy | ..... | ..... | 1,204,026 | 17.5 |
| Superior | 212,051 | 18.23 | 185,315 | 16.38 |
| Tamarack | 217,027 | 17.9 | ..... | ..... |
| Trimountain | 349,684 | 23.75 | 349,504 | 24.94 |
| Victoria | 133,984 | ..... | 146,690 | ..... |
| White Pine | [a] 114,039 | 24.76 | 128,890 | 22.27 |
| Winona | 102,594 | 16.79 | 161,828 | 13.39 |
| Wolverine | 397,614 | 18.23 | 388,898 | 17.07 |

[a] Last eight months of 1915.

*Copper produced by Michigan mines in 1915 and 1916, compiled from the annual reports of the producing companies.*

| Company. | Quantity (pounds). | | Cost per pound. | Price received per pound. | Profit per pound. |
|---|---|---|---|---|---|
| | 1915 | 1916 | | | |
| | | | *Cents.* | *Cents.* | *Cents.* |
| Ahmeek | 21,800,492 | 24,142,158 | 11.54 | 25.72 | 14.18 |
| Allouez | 10,043,459 | 10,219,290 | 10.85 | 25.305 | 14.455 |
| Baltic | 12,028,947 | 12,425,804 | 10.85 | 25.28 | 14.43 |
| Calumet & Hecla | 71,030,518 | 71,349,591 | 11.63 | 25.48 | 13.85 |
| Centennial | 2,347,500 | 2,367,400 | 13.44 | 25.02 | 11.58 |
| Champion | 33,407,599 | 33,601,136 | 7.80 | 25.28 | 17.48 |
| Franklin | 1,314,969 | 3,116,566 | ..... | 25.432 | ..... |
| Hancock | 871,124 | 2,824,934 | ..... | 28.093 | ..... |
| Houghton | 156,766 | 204,274 | ..... | 29.21 | ..... |
| Isle Royale | 9,342,106 | 12,412,111 | 15.75 | 25.86 | 10.11 |
| Keweenaw | ..... | 68,880 | ..... | ..... | ..... |
| La Salle | 782,493 | 1,380,352 | 20.96 | 25.68 | 4.72 |
| Mass | 4,638,452 | 4,752,588 | 15.37 | 26.276 | 10.906 |
| Mohawk | 15,882,914 | 13,834,034 | 8.85 | 25.28 | 16.43 |
| Osceola | 19,731,472 | 19,586,501 | 11.69 | 25.73 | 14.04 |
| Quincy | 22,054,813 | 21,065,612 | ..... | 25.50 | ..... |
| Superior | 3,866,434 | 3,084,656 | 14.61 | 24.67 | 10.06 |
| Tamarack | 3,888,150 | ..... | ..... | ..... | ..... |
| Trimountain | 8,302,896 | 8,720,558 | 11.01 | 25.28 | 14.27 |
| Victoria | 1,499,695 | 1,661,832 | ..... | ..... | ..... |
| White Pine | 2,824,145 | 4,207,449 | 12.70 | 25.26 | 12.56 |
| Winona | 1,722,638 | 2,167,255 | ..... | 28.03 | ..... |
| Wolverine | 7,250,866 | 6,641,492 | 9.54 | 20.62 | 11.08 |
| Average | ..... | ..... | 11.17 | 25.41 | 14.24 |

The regrinding plants that have been generally introduced in the mills have effected a notable increase in the recovery of copper and during 1916 a leaching plant for treatment of tailings was placed in operation by the Calumet & Hecla Co. This proved so successful that an enlargement of the plant was undertaken. Experiments with flotation processes for the treatment of the ores are also being carried on.

The district is well located for cheap working of the mines. The Great Lakes furnish cheap transportation for both coal and copper, and the Lake steamers reach the heart of the district by Portage Lake and the Houghton Ship Canal. The district is served by the Mineral Range, Copper Range, and Keweenaw Central railroads and is connected with the main lines of traffic by the Chicago, Milwaukee & St. Paul and Duluth, South Shore & Atlantic railways.

## MONTANA.

The output of blister copper from Montana in 1916 was 352,139,768 pounds, compared with 268,263,040 pounds in 1915.

The first record of production of copper from Montana was in 1868, but the State did not become a large contributor of this metal until 1880. Since that time the increase in its output of copper has been steady and rapid. To the end of 1916 the State has produced 7,055,236,907 pounds, or 30.26 per cent of the total output of the United States since 1845. In total production the State ranks first, and in the output for 1916 it ranked second. The Butte district has furnished nearly the entire output.

Three copper-smelting plants were operated in Montana in 1916—that of the East Butte Mining Co. at Butte, and those of the Anaconda Copper Co. at Anaconda and at Great Falls.

*Butte district.*—The presence of copper minerals in the Butte district has been known since the discovery of gold there in 1864, and attempts were made to treat the copper ores as early as 1866; but it was not until the late seventies that Butte began to attract attention as a copper camp, and large production did not begin until a railroad reached the district in 1881. To the end of 1916 Butte has produced about 7,030,000,000 pounds of copper, or 30.16 per cent of the total output of the country since 1845. Both in total production and in the output in 1916 it ranks first among the copper-producing districts of the United States.

*Copper and associated metals produced in Butte district, Mont., 1906–1916.*

| Year. | Copper. | Average yield in copper. | Gold. | Silver. | Year. | Copper. | Average yield in copper. | Gold. | Silver. |
|---|---|---|---|---|---|---|---|---|---|
| | *Pounds.* | *Per cent.* | *Ounces per ton.* | *Ounces per ton.* | | *Pounds.* | *Per cent.* | *Ounces per ton.* | *Ounces per ton.* |
| 1906..... | 294,000,000 | 3.15 | 0.01 | 2.0 | 1912.... | 308,000,000 | 3.02 | 0.0065 | 2.09 |
| 1907..... | 222,000,000 | 2.75 | .014 | 2.3 | 1913.... | 283,600,000 | 2.70 | .0058 | 1.92 |
| 1908..... | 252,500,000 | 3.3 | .0075 | 2.16 | 1914.... | 235,700,000 | 2.66 | .0059 | 1.82 |
| 1909..... | 314,000,000 | 3.08 | .0076 | 2.07 | 1915.... | 267,000,000 | 2.66 | .0066 | 1.82 |
| 1910..... | 282,500,000 | 3.13 | .0068 | 2.02 | 1916.... | 349,500,000 | 2.81 | .0059 | 1.79 |
| 1911..... | 271,200,000 | 3.17 | .0071 | 2.20 | | | | | |

*Copper, gold, and silver produced by Anaconda Copper Mining Co. from company ores, 1913–1916.*

| Year. | Ore treated. | Copper. | Silver. | Gold. | Dividends. |
|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Ounces.* | *Ounces.* | |
| 1913..... | 4,566,451 | 241,983,323 | 8,719,132 | 64,898 | $12,997,500 |
| 1914..... | 3,768,640 | 205,298,531 | 7,221,815 | 99,651 | 9,077,500 |
| 1915..... | 4,258,129 | 235,076,289 | 8,064,986 | 106,702 | 9,325,000 |
| 1916..... | 5,273,066 | 307,395,092 | 10,790,706 | 92,099 | 17,484,375 |

During 1916 the Anaconda Co. acquired the Pilot Butte, Butte-Alex Scott, and some other claims.

Developments of 42.06 miles were very satisfactory as to ore opened, especially in the deep levels of the Leonard mine in the eastern, the Diamond mine in the northern, and the Mountain Consolidated in the northwestern portions of the district.

The annual report of the company states that

The mines of the company produced during the year 5,582,076.52 tons of ore and 7,080.96 tons of precipitates, a total of 5,589,157.48 tons.

The copper reduction works treated for all companies during the year 5,193,572.64 tons of ore and other cupriferous material at Anaconda, and 813,495.53 tons of ore and other cupriferous material at Great Falls.

Of this amount 5.273,065.96 tons of ore were produced by company mines; 724,355.35 tons of ore were either purchased from or treated for other companies; 9,646.86 tons of precipitates and cleanings from the old works at Anaconda and Butte were treated.

At Anaconda there were produced 287,082,079 pounds of fine copper, 10,624,747.20 ounces of silver, and 81,393.059 ounces of gold.

At Great Falls there were produced 44,811,194 pounds of fine copper, 1,213,022.03 ounces of silver, and 10,706.123 ounces of gold.

Or a total production at both Anaconda and Great Falls copper plants of 331,893,273 pounds of fine copper, 11,837,769.23 ounces of silver, and 92,099.182 ounces of gold.

Of the total production at these plants, 307,395,092 pounds of fine copper, 10,790,705.67 ounces of silver, and 92,099,182 ounces of gold were produced from the mines of your company.

A total of 20,906,439 pounds of electrolytic zinc was produced at Anaconda and Great Falls.

The new copper electrolytic and furnace refineries at Great Falls were completed and began operation in March, 1916. At the close of the year the electrolytic refinery was producing at the rate of 16,000,000 pounds of copper per month.

The leaching plant at Anaconda treated 525,500 tons of tailings from the concentrator dump, from which there was produced 3,648 tons of cement copper. The results of the recent improvements in the metallurgical plant were very apparent in 1916. Since the year 1914, inclusive, $13,645,908 has been expended in improvements. To the close of 1916 the additional profit that had resulted amounted to $16,494,485. The increased saving in metal amounted to 40,641,265 pounds of copper, 1,412,522 ounces of silver, and 3,514 ounces of gold from copper ores treated. The recovery in concentrates of ore treated at Anaconda was increased from 75.578 per cent to 95.896 per cent, and the recovery of copper from smelting ore was increased from 78.182 per cent to 90.521 per cent.

Total profits of the Anaconda Copper Mining Co. for 1916 were $50,828,372. Dividends were declared amounting to $17,484,375.

*Copper, silver, and gold produced by North Butte Mining Co., 1912–1916.*

| Year. | Copper ore and precipitates treated. | Copper. | Silver. | Gold. | Dividends. |
|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Ounces.* | *Ounces.* | |
| 1912 | 425,297 | 26,480,123 | 1,377,468 | 1,367 | $697,000 |
| 1913 | 455,029 | 28,318,321 | 1,602,163 | 1,567 | 820,000 |
| 1914 | 337,415 | 18,421,761 | 1,092,300 | 1,107 | 635,000 |
| 1915 | 378,161 | 19,235,285 | 940,631 | 1,121 | 387,000 |
| 1916 | 544,456 | 24,498,181 | 1,047,063 | 1,712 | 1,075,000 |

During the last two months of the year there were treated 1,625 tons of zinc ore, which produced 412,953 pounds of zinc and 2,510 ounces of silver.

The ore reserves at the close of the year were estimated as larger than at the close of 1915.

The cost per pound of copper for the year was 15.57 cents.

Net earnings amounted to $2,479,595. Dividends were paid to the amount of $1,075,000.

*Copper produced by East Butte Copper Mining Co., 1912–1916.*

| Year. | Ore mined. | Average copper content. | Copper produced by smelter. | Average cost per pound of copper. |
|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Pounds.* | *Cents.* |
| 1912 | 99,458 | 5.78 | 14,709,460 | 9.698 |
| 1913 | 105,071 | 5.16 | 14,401,108 | 11.040 |
| 1914 | 72,853 | 4.72 | 9,175,578 | 11.110 |
| 1915 | 150,911 | 4.28 | 12,542,058 | 11.853 |
| 1916 | 258,899 | 3.67 | 18,340,713 | 16.887 |

During the year the Tuolumne mine produced 26,371 tons of ore averaging 2.767 per cent copper, 3.005 ounces silver, and 0.0075 ounce gold per ton.

## NEVADA.

The production of blister copper in Nevada in 1916 was 100,816,724 pounds, compared with 67,757,322 pounds in 1915.

The earliest recorded production of copper in Nevada was in 1873, but the State did not become an important factor in the copper industry until 1908, when production from the Ely district began. To the end of 1916 Nevada has a recorded production of 600,820,498 pounds, or 2.58 per cent of the output of the country since 1845. In total production and in the output for 1916 Nevada ranks sixth among the copper-producing States.

A large part of the output has come from two districts, the Ely district, in White Pine County, and the Yerington district, in Lyon County.

*Ely district.*—The Ely district, White Pine County, had the largest production of copper in Nevada in 1916. Although it had long been known that the district contained copper deposits, production did not begin until 1908, when the Steptoe Valley smelting and concentrating plant was completed.

*Mine production of metals in Ely district, Nev., 1908–1916.*

| Year. | Ore. | Copper in concentrates. | Average yield in copper. | Gold and silver per ton of ore. |
|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Per cent.* | *Cents.* |
| 1908 | 429,925 | 14,776,363 | 1.72 | 24 |
| 1909 | 1,671,225 | 51,700,000 | 1.72 | 24 |
| 1910 | 2,346,354 | 62,332,419 | 1.30 | 21 |
| 1911 | 2,745,524 | 65,262,796 | 1.19 | 17 |
| 1912 | 2,985,217 | 64,932,446 | 1.09 | 17 |
| 1913 | 3,419,178 | 69,950,350 | 1.02 | 13.4 |
| 1914 | 2,749,913 | 51,089,921 | .93 | 16 |
| 1915 | 3,172,355 | 64,638,158 | 1.02 | 19 |
| 1916 | 4,053,950 | 93,044,578 | 1.14 | 20 |

To the end of 1916 the output has been about 534,124,000 pounds. The district has yielded 2.29 per cent of the total output of the country since 1845, and it produced 4.64 per cent of the output in 1916. Both in total production and in the production for 1916 it ranks eighth among the copper districts of the country.

*Metals produced by Nevada Consolidated Copper Co., 1909–1916.*

| Year. | Ore treated. | Average assay of copper. | Average extraction of copper. | Gold and silver recovered per ton. | Refined copper produced. | Average cost of copper per pound. | Dividends. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Per cent.* | *Cents.* | *Pounds.* | *Cents.* | |
| 1909 [a] | [b] 1,065,385 | 2.34 | 70.73 | 23.12 | 34,527,823 | 7.14 | |
| 1910 [c] | [b] 2,237,028 | 2.06 | 69.59 | 21.14 | 60,513,009 | 7.37 | $2,982,644 |
| 1911 [d] | 3,338,242 | 1.80 | 67.59 | 17.35 | 78,541,270 | 7.17 | 3,746,995 |
| 1912 | 2,852,515 | 1.692 | 68.25 | 16.48 | 63,063,261 | 8.86 | 2,999,137 |
| 1913 | 3,139,137 | 1.599 | 68.52 | 12.32 | 64,972,829 | 9.99 | 2,999,185 |
| 1914 | 2,640,294 | 1.483 | 68.48 | 13.45 | 49,244,056 | 10.16 | 2,249,389 |
| 1915 | 3,081,520 | 1.54 | 70.18 | 18.56 | 62,726,651 | 8.67 | 2,999,185 |
| 1916 | 3,922,634 | 1.632 | 73.87 | 20.44 | 90,735,287 | 10.17 | 7,497,963 |

[a] Year to Sept. 30, 1909.
[b] Steptoe Valley Smelting & Mining Co.
[c] Year to Sept. 30, 1910.
[d] Sept. 30, 1910, to Dec. 31, 1911, inclusive.

Ore reserves at the close of the year were estimated at 67,993,117 tons, averaging 1.59 per cent copper. Net profits for the year were $15,435,359.

The Consolidated Coppermines Co. for the fiscal year ending April 30, 1916, produced 81,303 tons of ore, yielding 1,646,502 pounds of copper, 556 ounces gold, and 1,445 ounces silver, with a total value of $356,318.

Ore reserves at the close of the year were estimated as 25,867,850 tons, carrying an average of 1.141 per cent copper.

*Yerington district.*—The Yerington or Mason district is in Lyon County, 50 miles southeast of Reno. It includes the productive portion of the Singatse Range, a low desert range lying between Mason Valley on the east and Smith Valley on the west.

The district did not commence to produce on a large scale prior to 1912.

*Copper produced in Yerington district, Nev., 1912–1916.*

| | Pounds. | | Pounds. |
|---|---|---|---|
| 1912 | 14,700,000 | 1915 | 700,000 |
| 1913 | 14,400,000 | 1916 | 3,491,000 |
| 1914 | 7,480,000 | | |

The smelter of the Mason Valley Mines Co., at Thompson, was not operated in 1916, but was blown in February 13, 1917, to be operated on company and custom ores.

The Nevada-Douglas Consolidated Copper Co. shipped ore during the year and had under construction a leaching plant for the treatment of its ores.

*Other districts.*—Production was made by the Santa Fe district, Mineral County; Goldfield, Railroad, and Contact districts, Elko County; Jack Rabbit district, Lincoln County; Battle Mountain district, Humboldt County; Yellow Pine district; and smaller production from many other districts.

## NEW MEXICO.

The production of blister copper from New Mexico in 1916 was 79,863,439 pounds, compared with 62,817,234 pounds in 1915.

Production of copper from New Mexico began in the last years of the eighteenth century, native copper from the mines of Grant County being carried to Mexico City and coined into money. During the nineteenth century, however, there was but small output. A little copper was reported for the year 1860, but New Mexico did not have a steady output until after 1880 and did not become a large producer until 1912.

From 1845 to 1916 New Mexico had a recorded output of 381,436,220 pounds of copper, or 1.64 per cent of the total output of the country. The principal producing districts are those of Grant County.

*Santa Rita district.*—The Santa Rita district was probably the first district in the West in which there was any notable production of copper; the output began in the closing years of the eighteenth century, and the metal went to Mexico for coinage. There are no accurate records of the production for this early period of operation,

but from the best sources available it is estimated that the total production to the end of 1916 has been 373,139,000 pounds.

*Copper produced in Santa Rita district, N. Mex., 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 3,075,000 | 1910 | 2,670,000 | 1914 | 54,000,000 |
| 1907 | 5,000,000 | 1911 | 1,400,000 | 1915 | 65,000,000 |
| 1908 | 4,000,000 | 1912 | 25,000,000 | 1916 | 74,228,000 |
| 1909 | 3,300,000 | 1913 | 50,511,000 | | |

Since 1909 the Chino Copper Co. has been actively developing the main mineralized area by means of churn drills, and production by this company began late in 1911.

*Metals produced by Chino Copper Co., 1911–1916.*

| Year. | Ore milled. | Copper content. | Mill recovery. | Production of refined copper. | Gold and silver per ton. | Cost of copper per pound. | Dividends. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Per cent.* | *Pounds.* | *Cents.* | *Cents.* | |
| 1911 | | | | 986,375 | | | |
| 1912 | 1,120,375 | 2.077 | 61.63 | 27,776,088 | | 7.69 | |
| 1913 | 1,942,700 | 2.033 | 67.31 | 50,511,661 | | 8.78 | $1,919,070 |
| 1914 | 1,907,300 | 2.115 | 67.858 | 53,999,928 | 2.71 | 7.60 | 2,169,065 |
| 1915 | 2,379,800 | 2.155 | 66.588 | 64,887,788 | 3.35 | 7.12 | 2,609,860 |
| 1916 | 3,094,400 | 1.83 | 66.59 | 72,319,508 | 2.60 | 8.70 | 7,177,335 |

The company reports ore reserves at the close of 1916 as 95,555,843 tons, containing an average of 1.656 per cent copper. Total ore developed amounted to 106,081,263 tons, averaging 1.694 per cent copper, of which 11,590,327 tons, averaging 2.01 per cent copper, had been mined at the close of 1916. Net profits for the year were $12,843,161.73.

*Burro Mountain district.*—The Burro Mountain district, southwest of Silver City, produced about 8,392,000 pounds of copper in 1916. The total production from the district has probably been about 19,792,000 pounds.

The gross production of copper from the mines of the Burro Mountain Copper Co. was 8,587,398 pounds. The concentrating plant began operation April 12. During the year its capacity was increased to 1,400 tons daily.

*Operations of the concentrator of the Burro Mountain Copper Co., 1916.*

| | Quantity (tons, dry weight). | Average assay (per cent copper). |
|---|---|---|
| Ore milled | 253,782 | 2.117 |
| Concentrates produced | 26,362 | 13.937 |
| Tailings produced | 227,420 | .736 |
| Saving | | 68.39 |
| Ratio of concentration | | 9.627 |
| Actual running time, 213 days, 9 hours, 25 minutes. | | |
| Ore milled per day, actual running time | tons.. | 1,189.34 |
| Fresh water used per ton ore milled | gallons.. | 838.15 |
| Power used, per ton ore milled | kilowatt hours.. | 8.997 |

The average recovery of copper from concentrates in November was 77.16 per cent and in December it was 76.32 per cent of the copper content of the ore.

*Lordsburg district.*—The Lordsburg district, in central Grant County, has been a steady producer of copper for several years.

*Copper produced in Lordsburg district, N. Mex., 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 210,000 | 1910 | 1,600,000 | 1914 | 2,614,000 |
| 1907 | 460,000 | 1911 | 2,400,000 | 1915 | 3,890,000 |
| 1908 | 250,000 | 1912 | 3,000,000 | 1916 | 4,755,000 |
| 1909 | 589,000 | 1913 | 1,600,000 | | |

Other districts that made notable production in 1916 were the Oro Grande and the Magdalena.

## TENNESSEE.

The production of blister copper in Tennessee in 1916 was 14,556,278 pounds, compared with 18,205,308 pounds in 1915.

The entire output came from the Ducktown district, in the extreme southeastern part of the State, in Polk County. The district was one of the earliest large producers in the country. Operations began about 1850, and from that date till the end of the Civil War there was a large production from the "black-copper" ores. With the exhaustion of the rich secondary deposits attempts were made to work the lean original sulphides. These efforts met with only indifferent success, and in the late seventies the smelters shut down, thus ending the first period of activity in this district. The present period of activity began in 1890, when the Ducktown Sulphur, Copper & Iron Co. began operations. Since that time the district has been a steady producer from the primary sulphide ores. To the end of 1916 the total output of the district has been 319,966,000 pounds.

*Metals produced in Ducktown district, Tenn., 1906–1916.*

| Year. | Ore treated. | Copper produced. | Average yield of copper. | Gold and silver per ton of ore. |
|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Per cent.* | *Cents.* |
| 1906 | 538,141 | 17,809,442 | 1.7 | 8 |
| 1907 | 558,487 | 19,475,119 | 1.77 | 7 |
| 1908 | 618,806 | 19,710,103 | 1.55 | 5 |
| 1909 | 576,680 | 19,207,747 | 1.66 | 6 |
| 1910 | 552,796 | 16,691,777 | 1.52 | 8 |
| 1911 | 581,974 | 18,965,143 | 1.62 | 11.7 |
| 1912 | 603,229 | 18,395,256 | 1.53 | 10.5 |
| 1913 | 652,253 | 19,489,654 | 1.476 | 11.2 |
| 1914 | 653,621 | 18,661,112 | 1.435 | 9 |
| 1915 | 623,534 | 18,205,308 | 1.45 | 9 |
| 1916 | 482,496 | 14,556,278 | 1.52 | 14 |

A part of the copper has been marketed without refining and without recovering the gold and silver contained. This accounts in large part for the variation in the gold and silver recovered per ton of ore treated.

The fact that the ores can be extracted with little timbering, the cheap supply of coke and coal from Tennessee and West Virginia,

and the comparatively low cost of labor have made it possible to mine and treat these low-grade ores at a profit.

The pyritic process of smelting is practiced successfully by both the Ducktown Sulphur, Copper & Iron Co. and the Tennessee Copper Co. The low-grade matte produced by the first smelting is resmelted and brought to a proper grade for conversion.

Sulphuric acid plants were operated by both companies. The successful operation of these plants has not only helped to solve the troublesome smelter-smoke problem but has added very materially to the revenue of the companies. The production of sulphuric acid will probably be fully as important in the future as the output of copper.

The companies of the district are limited in their output of copper by the fact that some sulphur fumes necessarily escape into the air and the volume that may be permitted to escape is limited by order of the courts. Experiments are being carried on by the Ducktown Sulphur, Copper & Iron Co. with a view to treating the fumes that can not be utilized in the acid plant so as to recover the elemental sulphur in them.

The Ducktown Sulphur, Copper & Iron Co. has a small electrolytic plant for the recovery of zinc as a by-product and the Tennessee Copper Co. also is investigating processes looking to the recovery of by-product zinc.

*Copper and acid produced by Tennessee Copper Co., 1911–1916.*

| Year. | Ore smelted. | Copper. | Sulphuric acid, 60° Baumé. | Cost of copper per pound. | Dividends. |
|---|---|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Short tons.* | *Cents.* | |
| 1911 | 436,285 | 13,808,940 | ..... | 10.88 | $300,000 |
| 1912 | 444,289 | 13,252,634 | 192,084 | 11.00 | 500,000 |
| 1913 | 470,135 | 13,493,140 | 197,712 | 11.34 | 750,000 |
| 1914 | 485,051 | 12,871,113 | 210,163 | 11.84 | 600,000 |
| 1915 | 475,301 | 12,750,418 | 210,666 | 10.53 | 600,000 |
| 1916 | 385,188 | 9,404,295 | 181,637 | 14.36 | 150,000 |

The company's reserves of ore in the Burra Burra, London, and Polk County mines at the end of 1916 were estimated at 3,372,305 tons.

*Copper and acid produced by Ducktown Sulphur, Copper & Iron Co., 1913–1916.*

| Year. | Ore treated. | Copper. | Sulphuric acid, 60° Baumé. |
|---|---|---|---|
| | *Short tons.* | *Pounds.* | *Short tons.* |
| 1913 | 182,000 | 5,992,000 | ..... |
| 1914 | 169,000 | 5,862,000 | 45,770 |
| 1915 | 150,400 | 5,370,000 | 41,295 |
| 1916 | ..... | ..... | ..... |

The Ducktown Co. estimated at the close of 1915 that its ore reserves at the Mary mine amounted to 1,000,000 tons, averaging not less than 2 per cent copper and 17 per cent sulphur. The East Tennessee mine was reported as capable of producing 30,000 tons of ore,

averaging in excess of 2½ per cent copper and 8 per cent sulphur. The Isabella mine had reserves of 2,500,000 tons, averaging 29 per cent sulphur and 0.8 per cent copper.

The district is served by a branch line of the Louisville & Nashville Railroad, with which the mines and smelters of the companies are connected by private line.

## UTAH.

In 1916 Utah produced 232,335,950 pounds of blister copper, compared with 175,177,695 pounds in 1915.

The first recorded production of copper from Utah was in 1870, but the State did not become a large copper producer until about 1900. Since that time the growth of the industry has been steady and rapid. The total recorded output from the State to the end of 1916 is 1,649,731,595 pounds, or 7.08 per cent of the output of the United States since 1845. In 1916 Utah produced 12.05 per cent of the output. In total output and in the production for 1916 it ranks fourth among the copper-producing States.

Two copper-smelting plants were operated in the State during 1916—the Garfield smelter, at Garfield, and the International smelter, at Tooele.

*Bingham district.*—The presence of copper minerals in the Bingham district has been known since the early days of mining in the district, but for many years operations were confined to the production of lead, silver, and gold, and not until 1896 did the mining of copper ore become of commercial importance. To the end of 1916 the district has produced approximately 1,373,100,000 pounds of copper, or 5.89 per cent of the output of the country since 1845. For 1916 the district yielded 11.15 per cent of the total production. In total output the district ranks fourth among those of the country and in the production for 1916 it ranks third.

*Copper produced in Bingham district, Utah, 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 39,000,000 | 1910 | 112,000,000 | 1914 | 150,000,000 |
| 1907 | 47,000,000 | 1911 | 125,000,000 | 1915 | 165,000,000 |
| 1908 | 56,000,000 | 1912 | 112,000,000 | 1916 | 223,619,000 |
| 1909 | 86,000,000 | 1913 | 132,000,000 | | |

The concentrating ore of the district is treated at the mills at Garfield and Lark. The ores and concentrates are smelted at the Garfield and International smelters.

*Metals produced by Utah Copper Co., 1911–1916.*

| Year. | Ore milled. | Copper content. | Mill recovery. | Refined copper. | Gold and silver per pound of copper. | Cost per pound of copper. | Dividends. |
|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Per cent.* | *Pounds.* | *Cents.* | *Cents.* | |
| 1911 | 4,680,801 | 1.51 | 69.53 | 93,514,419 | 1.07 | 7.865 | $4,703,022 |
| 1912 | 5,315,321 | 1.36 | 66.32 | 91,366,237 | .95 | 9.024 | 4,729,747 |
| 1913 | 7,519,392 | 1.25 | 63.95 | 113,942,834 | .64 | 9.498 | 4,747,710 |
| 1914 | 6,470,166 | 1.42 | 66.04 | 115,690,445 | .75 | 8.131 | 4,827,885 |
| 1915 | 8,494,300 | 1.43 | 64.13 | 148,397,006 | .62 | 6.61 | 6,904,082 |
| 1916 | 10,944,000 | 1.43 | 62.34 | 187,531,824 | .65 | 6.95 | 19,493,880 |

The profits of the Utah Copper Co. for 1916 were $39,738,675.

At the end of 1916 development had been carried on over an area of 226.3 acres and ore estimated at 424,524,258 tons and carrying an average copper content of 1.415 per cent had been developed and partly developed. Of this ore 54,678,700 tons, carrying an average copper content of 1.449 per cent had been extracted prior to January 1, 1917, leaving ore reserves at that date of 369,845,558 tons, averaging 1.41 per cent copper.

The mills at Garfield treated an average of 30,038 tons of ore daily during 1916.

*Copper, gold, and silver produced by Utah Consolidated Mining Co., 1911–1916.*

| Year. | Ore. | Copper content. | Gold per ton. | Silver per ton. | Copper.[a] | Dividends. |
|---|---|---|---|---|---|---|
| | *Short tons.* | *Per cent.* | *Ounce.* | *Ounce.* | *Pounds.* | |
| 1911 | 162,522 | 2.891 | 0.0936 | 0.9815 | 9,162,023 | $150,000 |
| 1912 | 159,143 | 2.146 | .077 | .828 | 6,506,814 | 450,000 |
| 1913 | 181,077 | 1.987 | .056 | .705 | 7,710,668 | 450,000 |
| 1914 | 153,345 | 2.509 | .085 | .996 | 7,584,391 | 600,000 |
| 1915 | 207,119 | 2.22 | .075 | 1.02 | 8,836,091 | 600,000 |
| 1916 | 360,034 | 1.734 | .052 | .796 | 12,211,118 | 1,125,000 |

[a] Includes copper derived from lead ores.

In recent years the Utah Consolidated Co. has been a large producer of lead ores, the yield in 1916 being 18,175,709 pounds. At the end of the year there was "in sight" in the mine 180,000 tons of copper ore, carrying 1.77 per cent copper and averaging 0.048 ounce gold and 0.69 ounce silver per ton. The ore was shipped by aerial tram to the International smelter. The mine of the Ohio Copper Co. was operated, the ore being milled at the plant at Lark

Several other mines in the district yielded considerable quantities of copper and copper-lead ores, notably the Old Jordan mine of the United States Mining Co., the Yampa mine, the Bingham-New Haven mine, the Utah Apex, and other mines.

The district is served by a branch of the Denver & Rio Grande Railroad and by the Bingham & Garfield Railway, controlled by Utah Copper Co. interests, which connects the mines at Bingham with the mills at Garfield. Cable tramways are employed to considerable extent; the ores from the Utah Consolidated mines are delivered to the International smelter in this manner, and ores from other mines are delivered to the railroad over cable tramways.

*Tintic district.*—The production of copper from the Tintic district is largely incidental to the production of other metals. The quantity of ore in which copper is the most valuable metal constituent is relatively small. There has been a small output of copper from the district for many years, but no accurate statistics of the early output are available. It is estimated that to the end of 1916 the district has yielded 131,585,000 pounds of copper.

*Copper produced in Tintic district, Utah, 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 7,300,000 | 1910 | 9,600,000 | 1914 | 6,000,000 |
| 1907 | 7,800,000 | 1911 | 10,900,000 | 1915 | 5,350,000 |
| 1908 | 5,700,000 | 1912 | 13,000,000 | 1916 | 7,085,000 |
| 1909 | 6,000,000 | 1913 | 9,250,000 | | |

*Beaver County.*—The first notable production of copper from Beaver County came from the Horn Silver mine in 1889, and since that time copper has been produced from lead-silver ores and from small copper mines. The importance of the district as a copper camp dates from the starting of the mill in 1905 to treat ores of the Cactus mine. To the end of 1916 the district has yielded about 42,200,000 pounds of copper.

*Copper produced in Beaver County, Utah, 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 5,400,000 | 1910 | 1,100,000 | 1914 | 1,500,000 |
| 1907 | 4,900,000 | 1911 | 3,600,000 | 1915 | 425,000 |
| 1908 | 5,500,000 | 1912 | 3,000,000 | 1916 | 1,722,000 |
| 1909 | 1,200,000 | 1913 | 3,000,000 | | |

The largest output has been from the Cactus mine; other producers are the Horn Silver, O K, Old Hickory, and other mines.

Tailings from the old Cactus mill were treated by a flotation plant.

*Other districts.*—Considerable copper has been produced in the Park City, Big Cottonwood, Little Cottonwood, Ophir, and Rush Valley districts, where the metals of chief value are lead and silver.

## OTHER STATES.

*Georgia.*—In 1916 Georgia produced 803,699 pounds of copper. The productive area is adjacent to the Ducktown (Tenn.) copper district.

*Oregon.*—Oregon produced 2,433,567 pounds of blister copper in 1916, compared with 797,471 pounds in 1915. To the end of 1916 the State has a recorded output of 6,202,036 pounds of copper.

*Vermont.*—Vermont produced 324,400 pounds of copper, the largest production for several years.

*Virginia.*—Virginia produced 1,066,143 pounds of blister copper, principally from the Virgilina district.

*Washington.*—Washington produced 2,473,481 pounds of copper, as compared with 903,661 pounds in 1915.

*Wyoming.*—The production from Wyoming amounted to 1,784,351 pounds, as compared with 351,871 pounds in 1915.

## REFINERY PRODUCTION.

The refinery output of copper in the United States in 1916 was made by 13 plants, 9 of which employed the electrolytic method and 5 employed the furnace process on Lake Superior copper, the Calumet & Hecla plant employing both methods. Six of the large electrolytic refineries are on the Atlantic tidewater, and 5 Lake refineries are on the Great Lakes. Only 2 plants are located west of the Great Lakes—1 at Great Falls, Mont., and 1 at Tacoma, Wash. In addition to these refineries there are numerous plants in different parts of the country that make a considerable output from old copper, brass, and other alloys of copper. The output of the regular refining plants is in the form of casting, Lake, and electrolytic copper.

### CASTING AND PIG COPPER.

Blister copper that is low in precious metals and sufficiently free from impurities for certain uses is refined by the furnace proces, and ordinarily cast into ingots. This copper is usually unfit for uses requiring a high-grade copper, such as electric transmissions brass manufacture, and rolling, but is suitable for copper castings, and a large part of it is put to that use. Lake copper excepted, a comparatively small percentage of the copper output carries so small a content of precious metals that, together with the added value of electrolytic copper, it will not more than pay for the electrolytic refining of the copper; consequently the output of casting copper is small. Some blister or pig copper low in precious metals has been exported without further treatment and is probably consumed without electrolytic refining. A large percentage of the pig and casting copper shown in the table is from the Morenci-Metcalf district, Ariz. This district produces a rather high grade of blister copper carrying a small amount of precious metals, and it is found profitable to market much of it without electrolytic refining. During 1916 the production of furnace-refined new casting copper amounted to 12,469,050 pounds and of unrefined pig copper to 26,868,105 pounds.

### LAKE COPPER.

By lake copper, as the term is used in this report, is meant the output of the Lake smelters. A considerable portion of this output is refined electrolytically, but most of the electrolytically refined Lake copper is mixed with furnace-refined copper or is sold as some brand of Lake copper. Of the 269,868,105 pounds of copper produced by the Lake smelters, about 63,600,000 pounds were refined electrolytically, either to free the copper from impurities or to recover the silver content.

### ELECTROLYTIC COPPER.

Under electrolytic copper, as shown in the accompanying table, is included all new copper that was refined electrolytically, except that from the Lake district that was marketed as Lake copper. In 1916 the production of electrolytic copper from primary materials of domestic origin[1] amounted to approximately 1,579,620,513 pounds, and from materials of foreign origin to 370,635,116 pounds, and in addition 78,585,296 pounds was produced from secondary sources—a total electrolytic production of 2,028,840,925 pounds for the year.

### SECONDARY COPPER.

Under secondary copper is considered material recovered from remelting old copper, copper scraps, and copper recovered from the treatment of copper alloys or alloys that are treated without the separation of the copper. A canvass of plants producing secondary copper has been made by J. P. Dunlop, of the United States Geological Survey. Concerning the output of secondary copper[2] Dunlop says:

[1] The separation of refined copper into copper of domestic and foreign origin is only approximate.
[2] Dunlop, J. P., Secondary metals: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 45-46, 1917

The total quantity of secondary copper recovered in 1916, on the assumption that the brass remelted had an average copper content of 70 per cent was 350,000 tons, of which 52,212 tons (22,425 tons more than in 1915) was recovered by plants refining primary metals and the remainder by plants treating only secondary materials. The copper produced by smelters of the latter class includes 74,100 tons of pig copper, 14,000 tons of copper in alloys other than brass, and 210,000 tons of copper in remelted brass. These figures indicate an increase for 1916 of about 20,000 tons of pig copper, 113,750 tons of copper in brass, and a decrease of about 2,000 tons in alloys other than brass. At least 175,000 tons was recovered from clean scrap made in the course of manufacture of copper and brass ware, so that less than 175,000 tons was obtained from ashes, cinders, and scrap, or from material that had actually been used and discarded.

## REFINED COPPER.

The total production of new refined copper in 1916 was 2,259,000,000 pounds, an increase of 625,000,000 pounds over the output in 1915.

*Production of primary and secondary copper by regular refining plants in 1913, 1914, 1915, and 1916, in pounds.*

| | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|
| Primary: | | | | |
| Domestic: | | | | |
| Electrolytic | 1,022,497,601 | 991,573,073 | 1,114,345,342 | 1,579,620,513 |
| Lake | 155,715,286 | 158,009,748 | [a] 236,757,062 | 269,794,531 |
| Casting | 22,606,040 | 21,506,325 | 21,555,129 | 12,469,050 |
| Pig | 36,004,986 | 39,334,043 | 15,047,990 | 26,868,105 |
| | [b] 1,236,823,913 | [b] 1,210,423,189 | [b] 1,387,705,523 | [b] 1,888,752,199 |
| Foreign (electrolytic) | [b] 378,243,869 | [b] 323,358,205 | [b] 246,498,925 | [b] 370,635,116 |
| | 1,615,067,782 | 1,533,781,394 | 1,634,204,448 | 2,259,387,315 |
| Secondary: | | | | |
| Electrolytic | 14,862,577 | 27,702,928 | 38,156,789 | 78,585,296 |
| Casting | 22,360,182 | 4,224,052 | 21,417,901 | 25,838,511 |
| | 37,222,759 | 31,926,980 | 59,574,690 | 104,423,807 |
| Total output | 1,652,290,541 | 1,565,708,374 | 1,693,779,138 | 2,363,811,122 |

[a] Some Lake copper was refined at seaboard plants and doubtless marketed under some brand other than Lake. This has been excluded from the Lake copper.

[b] The separation of refined copper into metal of domestic and foreign origin is only approximate, as an accurate separation at this stage of manufacture is not possible.

In addition to the secondary material treated by the regular refining companies, plants that treated secondary material exclusively produced a total of about 595,000,000 pounds of copper as copper and in brass and other alloys of copper, a total production of 700,000,000 pounds from secondary sources. Of this total at least 300,000,000 pounds was produced by remelting clean scrap produced in the manufacture of copper and brass articles.

If the output of plants treating purely secondary material is added to the production of the regular refining companies, the contribution from plants in the United States to the world's supply of copper for 1916 is found to be 2,959,000,000 pounds.

*Refined copper produced in the United States, 1906–1916, in pounds.*

| Year. | From primary sources (domestic and foreign). | | | | From secondary sources (copper and copper in alloys). |
|---|---|---|---|---|---|
| | Electrolytic. | Lake. | Casting and pig. | Total. | |
| 1906 | 815,966,781 | 229,626,215 | 43,159,413 | 1,079,052,409 | ..... |
| 1907 | 802,471,434 | 213,452,129 | 58,943,647 | 1,032,516,247 | ..... |
| 1908 | 848,109,132 | 222,289,584 | 67,563,092 | 1,137,962,408 | ..... |
| 1909 | 1,101,894,864 | 227,005,923 | 62,120,067 | 1,391,021,454 | ..... |
| 1910 | 1,128,304,726 | 221,462,984 | 72,271,426 | 1,422,039,135 | ..... |
| 1911 | 1,156,111,987 | 218,185,236 | 59,577,803 | 1,433,875,026 | 214,000,000 |
| 1912 | 1,274,935,371 | 231,112,228 | 62,056,879 | 1,568,104,478 | 275,000,000 |
| 1913 | 1,400,741,470 | 155,715,286 | 58,611,026 | 1,615,067,782 | 273,000,000 |
| 1914 | 1,314,931,288 | 158,009,748 | 60,840,368 | 1,533,781,394 | 255,764,000 |
| 1915 | 1,360,844,267 | 236,757,062 | 36,603,119 | 1,634,204,448 | 392,274,000 |
| 1916 | 1,950,255,629 | 269,794,531 | 39,337,155 | 2,259,387,315 | 700,000,000 |

## COPPER SULPHATE.

The production of hydrous copper sulphate or bluestone by the copper refineries of the United States in 1916 was 55,622,345 pounds, having a copper content of 14,043,315 pounds, compared with 42,086,107 pounds of bluestone, having a copper content of 10,621,524 pounds, in 1915.

## STOCKS.

*Stocks of copper Jan. 1, each year, 1906–1917, in pounds.*

| Year. | Refined copper. | Blister and material in process of refining. | Year. | Refined copper. | Blister and material in process of refining. |
|---|---|---|---|---|---|
| 1906 | 118,224,028 | 110,000,144 | 1912 | 88,372,195 | 219,864,749 |
| 1907 | 46,497,181 | 135,310,239 | 1913 | 105,497,683 | 274,072,084 |
| 1908 | 125,745,796 | 175,254,659 | 1914 | 90,385,402 | 247,789,811 |
| 1909 | 121,876,759 | 234,013,843 | 1915 | 173,640,501 | 203,067,571 |
| 1910 | 141,486,244 | 266,754,808 | 1916 | 82,429,666 | 274,000,000 |
| 1911 | 122,803,656 | 245,218,530 | 1917 | 128,055,229 | 424,000,000 |

## IMPORTS.

The quantity of copper in unmanufactured form imported into the United States in 1916 was 462,335,980 pounds, according to the records of the Bureau of Foreign and Domestic Commerce. The imports in 1915 were 315,698,449 pounds. The following tables show the character and source of copper-bearing materials imported during 1915 and 1916:

*Copper imported into the United States in 1914 and 1915, in pounds.*

| Country. | Ore, matte, and regulus, copper content. | | Pigs, bars, ingots, plates, old, etc. | |
|---|---|---|---|---|
| | 1914 | 1915 | 1914 | 1915 |
| United Kingdom | ..... | 94,801 | 5,163,126 | 7,475,625 |
| Germany | 4,684,668 | ..... | ..... | 32,951 |
| Spain | 2,633,395 | 1,278,403 | 16,931,784 | 7,964,534 |
| Canada | 24,304,104 | 29,591,823 | 27,230,559 | 43,419,681 |
| Mexico | 15,495,694 | 14,707,724 | 43,193,868 | 17,531,986 |
| Chile | 30,562,839 | 33,435,039 | 23,814,659 | 36,313,505 |
| Cuba | 18,659,788 | 28,876,226 | ..... | 1,042,101 |
| Peru | ..... | 3,299,327 | 44,488,809 | 61,342,067 |
| Japan | ..... | ..... | 10,918,069 | 17,970,768 |
| Australia and Tasmania | ..... | 500 | 15,130,001 | 443,520 |
| Other countries | 8,460,836 | 3,047,598 | 14,678,628 | 7,830,270 |
| | 104,801,324 | 114,331,441 | 201,549,503 | 201,367,008 |

The copper imported as matte and blister included some copper of domestic origin that was treated in foreign plants during the year.

*Copper imported into the United States in 1916, in pounds.*

| Country. | Ore (copper content). | Concentrates (copper content). | Matte and regulus (copper content). | Unrefined block and copper in bars, pigs, or other forms. | Refined, in bars plates, rods, or other forms. | Old and clippings for remanufacture. | Composition metal, copper chief value. |
|---|---|---|---|---|---|---|---|
| United Kingdom | 463 | ..... | 567,134 | 1,554,649 | 1,937,184 | 203,072 | 37,560 |
| Germany | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Spain | 2,619,025 | ..... | 40,186 | 550,290 | ..... | ..... | ..... |
| Canada | 33,964,545 | 35,200 | 3,345,009 | 47,951,823 | ..... | 5,542,454 | 271,379 |
| Mexico | 3,464,522 | 29,314,152 | 746,885 | 61,756,726 | 9,359 | 590,948 | 34,090 |
| Chile | 34,806,620 | 336 | 9,701,366 | 70,762,349 | 5,789,764 | 220,464 | 62,082 |
| Cuba | 38,400,758 | 2,131,480 | 208,902 | ..... | ..... | 1,071,902 | 215,780 |
| Peru | 3,301,624 | ..... | 1,478,275 | 72,827,909 | ..... | 37,685 | 27,275 |
| Japan | 60,002 | ..... | ..... | 9,192,410 | 336,047 | ..... | ..... |
| Australia and Tasmania | 500 | ..... | ..... | ..... | ..... | ..... | ..... |
| Other countries | 8,260,846 | 1,272,706 | 1,067,318 | 4,331,159 | 338,876 | 1,784,863 | 110,027 |
| | 124,878,905 | 32,753,874 | 17,155,075 | 268,927,315 | 8,411,230 | 9,451,388 | 758,198 |

*Copper imported into the United States, 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 225,593,281 | 1910 | 344,435,771 | 1914 | 306,350,827 |
| 1907 | 252,620,054 | 1911 | 334,607,538 | 1915 | 315,698,449 |
| 1908 | 218,705,487 | 1912 | 410,241,295 | 1916 | 462,335,960 |
| 1909 | 321,801,114 | 1913 | 408,778,954 | | |

## EXPORTS.

The exports of metallic copper from the United States in 1916 amounted to 784,006,486 pounds, according to the Bureau of Foreign and Domestic Commerce. In addition the copper content of 105,847 long tons of ore, matte, and regulus was exported in 1916, compared with the content of 57,731 long tons in 1915. Exports of copper sulphate were 13,938,919 pounds in 1915 and 19,469,565 pounds in 1916.

*Domestic copper (ingots, bars, plates, and old) exported from the United States in 1913, 1914, 1915, and 1916, in pounds.*

| Country. | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|
| United Kingdom | 133,679,641 | 198,382,459 | 201,218,655 | 184,564,740 |
| Austria-Hungary | 34,648,205 | 26,989,548 | ..... | ..... |
| Belgium | 7,102,120 | 5,429,717 | ..... | ..... |
| France | 160,000,345 | 150,839,897 | 236,236,135 | 336,829,464 |
| Germany | 307,150,761 | 176,698,948 | ..... | ..... |
| Italy | 41,568,713 | 67,415,944 | 107,101,156 | 113,764,478 |
| Netherlands | 178,940,289 | 126,001,150 | 4,018,841 | 5,853,306 |
| Russia in Europe | 7,907,672 | 8,731,272 | 37,430,402 | 49,658,437 |
| Other Europe | 14,357,014 | 45,634,229 | 56,013,517 | 30,700,473 |
| Canada | 35,982,207 | 24,221,498 | 24,128,098 | 45,850,582 |
| Other countries | 4,904,125 | 9,736,260 | 15,771,151 | 16,785,006 |
| | [a] 926,241,092 | 840,080,922 | [b] 681,917,955 | [c] 784,006,486 |

[a] Includes sheets, rods, wires, etc.
[b] Does not include copper content of 311,442 pounds of concentrates and 1,556,186 pounds of ore.
[c] Does not include copper content of 965,940 pounds of concentrates and 4,818,828 pounds of ore.

The copper exported was in the following forms:

*Copper exported from the United States, 1915–16.*

| Kind. | Quantity (pounds). | Value. |
|---|---|---|
| *Six months ending June, 1915.* | | |
| Ore (copper content) | | |
| Concentrates (copper content) | 311,442 | $55,005 |
| Ore, matte, and regulus | | 107,207 |
| Pigs, ingots, bars | 287,151,773 | 44,422,634 |
| Plates and sheets | 19,282,699 | 3,104,851 |
| Rods and wire | 36,162,542 | 5,609,621 |
| All other | 6,540,106 | 1,040,319 |
| | 349,448,562 | 54,339,637 |
| *Six months ending December, 1915.* | | |
| Unrefined black blister and converter copper, bars, pigs, and other forms | 1,233,137 | 227,791 |
| Ore (copper content) | 1,556,186 | 290,913 |
| Refined in ingots, bars, rods, or other forms | 300,412,186 | 56,703,111 |
| Old and scrap | 154,560 | 24,561 |
| Plates and bars | 16,695,945 | 3,279,026 |
| Wire | 14,284,907 | 2,838,902 |
| All other | | 7,885,472 |
| | 334,336,921 | 71,249,776 |
| Grand total, 1915 | 683,785,483 | 125,589,413 |
| *1916* | | |
| Ore (copper content) | 4,818,828 | 1,006,826 |
| Concentrates (copper content) | 965,940 | 232,241 |
| Unrefined black blister and converter copper (bars, pigs, and other forms) | 18,263,118 | 5,193,278 |
| Refined in ingots, bars, rods, or other forms | 716,616,763 | 186,266,158 |
| Old and scrap | 815,825 | 203,493 |
| Plates and sheets | 24,843,435 | 6,874,571 |
| Wire | 23,467,345 | 6,386,674 |
| All other | | 25,752,591 |
| | 789,791,254 | 231,915,832 |

The value of the copper exported is stated by the Bureau of Foreign and Domestic Commerce as $146,377,621 in 1913, $117,633,145 in 1914, $117,703,941 in 1915, and $206,163,241 in 1916.

*Metallic copper exported from the United States, 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 454,752,018 | 1910 | 708,316,543 | 1914 | 840,080,922 |
| 1907 | 508,929,401 | 1911 | 786,553,208 | 1915 | 681,917,955 |
| 1908 | 661,876,127 | 1912 | 775,000,658 | 1916 | 784,006,486 |
| 1909 | 682,846,726 | 1913 | 926,241,092 | | |

## CONSUMPTION.

The apparent consumption of refined new copper in the United States in 1916 was 1,429,755,266 pounds. In 1915 it was 1,043,497,328 pounds. The method employed in determining the quantity of copper retained for domestic consumption is shown in the following table, which does not include stocks of copper held by consumers:

*Apparent domestic consumption of refined new copper in 1913, 1914, 1915, and 1916, in pounds.*

| | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|
| Total refinery output of new copper | 1,615,067,782 | 1,533,781,394 | 1,634,204,448 | 2,259,387,315 |
| Stock at beginning of year | 105,497,683 | 90,385,402 | 173,640,501 | 82,429,666 |
| Total available supply | 1,720,565,465 | 1,634,166,796 | 1,807,844,949 | 2,341,816,981 |
| Refined copper exported | [a]817,911,424 | [a]840,080,922 | [a]681,917,955 | [a]784,006,486 |
| Stocks at end of year | 90,385,402 | 173,640,501 | 82,429,666 | 128,055,229 |
| Total withdrawn from supply | 908,296,826 | 1,013,721,423 | 764,347,621 | 912,061,715 |
| Apparent consumption | 812,268,639 | 620,445,373 | 1,043,497,328 | 1,429,755,266 |

[a] Exports of pigs, ingots, bars, rods, etc., reported by the Bureau of Foreign and Domestic Commerc.

If to the 1,429,755,266 pounds of new refined copper is added the 594,423,807 pounds of secondary copper and copper in alloys produced during the year, it is found that a total of about 2,024,000,000 pounds of new and old copper was available for domestic consumption.

*Domestic consumption of new copper, 1906–1916.*

| | Pounds. | | Pounds. | | Pounds. |
|---|---|---|---|---|---|
| 1906 | 677,434,937 | 1910 | 732,405,180 | 1914 | 620,445,373 |
| 1907 | 487,771,625 | 1911 | 681,753,279 | 1915 | 1,043,497,328 |
| 1908 | 479,955,318 | 1912 | 755,978,332 | 1916 | 1,429,755,266 |
| 1909 | 688,565,243 | 1913 | 812,268,639 | | |

## USES.

No systematic attempt has been made to ascertain the proportion of the copper output of 1916 used in different industries, such as electric transmission, brass manufacture, and casting, but some idea of the quantities entering the different industries can be gained from the forms in which the output of the refineries was cast. The following table shows the approximate quantity of copper cast in the different forms during 1916 as reported by the refining companies. It will be noted that the total is not the same as the refinery output for 1916.

*Copper cast in different forms in 1916.*

| Form. | Quantity (pounds). | Per-centage. |
|---|---|---|
| Wire bars | 853,028,629 | 37 |
| Ingots and ingot bars | 873,281,265 | 38 |
| Cakes | 298,399,153 | 13 |
| Cathodes | 192,109,762 | 8 |
| Other forms | 92,676,974 | 4 |
| | 2,309,495,783 | 100 |

It may be assumed that a large portion of the 37 per cent cast as wire bars was used in the electric industry and that much of the 13 per cent cast as cakes was used for rolling. The other forms are less easily classified. The 8 per cent cast as cathodes, together with a considerable portion of the ingots, and probably some of the cakes, entered the brass industry, and a large quantity of copper ingots was used in casting. The refinery output for 1915 was cast as

follows: Wire bars, 37 per cent; ingots, 45 per cent; cakes, 9 per cent; cathodes, 6 per cent; other forms, 3 per cent. The most notable change was the relative decrease in ingots and increase in cakes.

## PRICES.

The average price received for copper delivered by the producers in 1916 and the price used by the United States Geological Survey in calculating the value of the copper output was 24.6 cents a pound. The average received by selling agencies for 2,150,000,000 pounds, as reported to the Geological Survey by selling agencies, was 24.58 cents a pound.

The following table shows the average quoted price of copper at New York as reported by the American Metal Market Co., and by the Engineering and Mining Journal:

*Average monthly prices at New York per pound of electrolytic copper in 1913, 1914, 1915, and 1916, in cents, as reported by the American Metal Market Co.*

| Month. | 1913 | 1914 | 1915 | 1916 | Month. | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|---|
| January | 16.755 | 14.45 | 13.71 | 24.10 | August | 15.68 | 12.415 | 17.22 | 27.36 |
| February | 15.27 | 14.67 | 14.57 | 27.46 | September | 16.55 | 12.085 | 17.79 | 28.26 |
| March | 14.925 | 14.335 | 14.96 | 27.44 | October | 16.54 | 11.40 | 17.86 | 28.64 |
| April | 15.48 | 14.34 | 17.09 | 29.31 | November | 15.47 | 11.74 | 18.83 | 32.22 |
| May | 15.63 | 14.13 | 18.60 | 29.81 | December | 14.47 | 12.93 | 20.35 | 33.84 |
| June | 14.85 | 13.81 | 19.71 | 27.49 | | | | | |
| July | 14.57 | 13.49 | 19.08 | 25.60 | Average | 15.52 | 13.315 | 17.47 | 28.46 |

*Average monthly prices at New York per pound of electrolytic copper, 1913, 1914, 1915, and 1916, as reported by the Engineering and Mining Journal.*

| Month. | 1913 | 1914 | 1915 | 1916 | Month. | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|---|
| January | 16.488 | 14.223 | 13.641 | 24.008 | August | 15.400 | (a) | 16.941 | 26.120 |
| February | 14.971 | 14.491 | 14.394 | 26.440 | September | 16.328 | (a) | 17.502 | 26.855 |
| March | 14.713 | 14.131 | 14.787 | 26.370 | October | 16.337 | (a) | 17.686 | 27.193 |
| April | 15.291 | 14.211 | 16.811 | 27.895 | November | 15.182 | 11.739 | 18.627 | 30.625 |
| May | 15.436 | 13.996 | 18.506 | 28.625 | December | 14.224 | 12.801 | 20.133 | 31.890 |
| June | 14.672 | 13.603 | 19.477 | 26.601 | | | | | |
| July | 14.190 | 13.223 | 18.796 | 23.865 | Average | 15.269 | 13.602 | 17.275 | 27.202 |

a Price not quoted.

The large difference in the average quoted price and the actual average price received is due to the fact that since shortly after the opening of the war much of the copper has been sold for future delivery and the price for such delivery may be very different from spot price at the time that the copper was sold.

# GOLD AND SILVER.

(GENERAL REPORT.)

By H. D. McCaskey and J. P. Dunlop.

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## PRODUCTION.

### DOMESTIC PRODUCTION.

The recovered output of gold and silver in the United States from domestic ores and gravels in 1916 is shown below:

*Approximate distribution, by producing States and Territories, of the production of gold and silver in the United States for 1916.*[a]

| State or territory. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Commercial value. |
| Alabama | 358 | $7,400 | | |
| Alaska | 780,037 | 16,124,800 | 1,266,317 | $833,000 |
| Arizona | 197,989 | 4,092,800 | 6,680,252 | 4,394,600 |
| California | 1,063,302 | 21,980,400 | 1,936,910 | 1,274,200 |
| Colorado | 928,075 | 19,185,000 | 7,551,761 | 4,967,900 |
| Georgia | 987 | 20,400 | | |
| Idaho | 51,195 | 1,058,300 | 11,570,399 | 7,611,500 |
| Illinois | | | 5,782 | 3,800 |
| Maryland | | | 153 | 100 |
| Michigan | | | 759,068 | 499,300 |
| Missouri | | | 128,960 | 84,800 |
| Montana | 209,386 | 4,328,400 | 14,046,054 | 9,240,100 |
| Nevada | 438,505 | 9,064,700 | 13,682,067 | 9,000,600 |
| New Hampshire | | | 935 | 600 |
| New Mexico | 65,306 | 1,350,000 | 1,729,917 | 1,138,000 |
| North Carolina | 1,113 | 23,000 | 1,738 | 1,100 |
| Oklahoma | | | 606 | 400 |
| Oregon | 91,985 | 1,901,500 | 221,887 | 146,000 |
| Philippine Islands | 73,249 | 1,514,200 | 17,643 | 11,600 |
| Porto Rico | 29 | 600 | | |
| South Carolina | 15 | 300 | | |
| South Dakota | 361,444 | 7,471,700 | 210,100 | 138,200 |
| Tennessee | 276 | 5,700 | 93,837 | 61,700 |
| Texas | 24 | 500 | 664,319 | 437,000 |
| Utah | 186,679 | 3,859,000 | 13,545,802 | 8,911,000 |
| Vermont | 14 | 300 | 1,964 | 1,300 |
| Virginia | 24 | 500 | 508 | 300 |
| Washington | 28,067 | 580,600 | 294,516 | 193,700 |
| Wyoming | 977 | 20,200 | 3,407 | 2,200 |
| | 4,479,056 | 92,590,300 | 74,414,802 | 48,953,000 |

[a] Gold value, $20.67+ per fine ounce. Average commercial (dealer's) price of silver 0.999 fine in 1916, 65.8 cents per fine ounce.

The figures in this table result from cooperation of the United States Bureau of the Mint and the United States Geological Survey and are agreed upon after conference and adjustment between the two bureaus. They are, therefore, final for both.

The totals are based on bullion deposits in the United States mints and assay offices and on returns to the Bureau of the Mint from the smelting and refining companies. The distribution is adjusted by information collected by the United States Geological Survey directly from the producing mines and tabulated for the mines reports later discussed. The data giving the total production, and in part the distribution, are obtained from records of (1) the unrefined domestic gold and silver deposited in United States mints and assay offices, (2) the domestic gold and silver in fine bars reported by private refineries, and (3) the unrefined domestic gold and silver contained in ores and matte exported for reduction. The last item is of small relative importance.

*Increase or decrease in production of gold and silver in the United States in 1916.*

| State or Territory. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Commercial value. |
| Alabama | + 111 | + $2,300 | | |
| Alaska | − 28,309 | − 585,200 | + 211,683 | + 306,900 |
| Arizona | − 22,403 | − 463,100 | +1,014,580 | +1,568,100 |
| California | − 27,429 | − 567,000 | + 246,986 | + 431,100 |
| Colorado | −161,852 | −3,345,800 | + 352,016 | +1,376,000 |
| Georgia | − 696 | − 14,400 | − 141 | − 100 |
| Idaho | − 5,433 | − 112,300 | −1,472,067 | +1,104,700 |
| Illinois | | | + 1,890 | + 1,900 |
| Maryland | | | + 153 | + 100 |
| Michigan | | | + 177,194 | + 209,100 |
| Missouri | | | + 73,326 | + 57,100 |
| Montana | − 31,439 | − 649,900 | − 377,119 | +2,044,500 |
| New Hampshire | | | + 935 | + 600 |
| Nevada | −136,369 | −2,819,000 | − 771,018 | +1,790,100 |
| New Mexico | − 5,326 | − 110,100 | − 607,147 | − 27,900 |
| North Carolina | − 7,145 | − 147,700 | + 242 | + 400 |
| Oklahoma | | | + 606 | + 400 |
| Oregon | + 1,664 | + 34,400 | + 96,388 | + 83,400 |
| Philippine Islands | + 9,351 | + 193,300 | + 2,495 | + 4,000 |
| Porto Rico | − 5 | − 100 | | |
| South Carolina | − 150 | − 3,300 | | |
| South Dakota | + 3,299 | + 68,200 | + 12,531 | + 39,600 |
| Tennessee | − 53 | − 1,100 | − 5,334 | + 12,200 |
| Texas | − 63 | − 1,300 | − 60,261 | + 75,500 |
| Utah | − 2,366 | − 48,900 | + 472,331 | +2,388,800 |
| Vermont | + 14 | + 300 | + 1,814 | + 1,200 |
| Virginia | | | + 508 | + 300 |
| Washington | + 5,757 | + 119,000 | + 80,639 | + 87,000 |
| Wyoming | + 305 | + 6,300 | + 497 | + 800 |
| Increase or decrease | −408,546 | −8,445,400 | − 546,273 | +11,555,700 |

In addition to the production of gold and silver by domestic smelters and refiners from domestic sources in 1916, amounting to 4,479,056 fine ounces of gold and 74,414,802 fine ounces of silver, these plants produced 800,805 fine ounces of gold and 46,251,017 fine ounces of silver from foreign ores. These figures represent decrease in all items compared with the corresponding figures for 1915. The foreign ores producing this bullion were mainly from Mexico and Canada.

## PRICES OF SILVER.

The average official monthly prices of fine bar silver in New York in 1916 were as follows:

*Price of silver per fine ounce in 1916, by months.*[1]

| | | | |
|---|---|---|---|
| January | $0.5690 | August | $0.6620 |
| February | .5688 | September | .6864 |
| March | .5784 | October | .6798 |
| April | .6454 | November | .7174 |
| May | .7438 | December | .7589 |
| June | .6515 | | |
| July | .6306 | Yearly average | .65784 |

The average annual price of silver per fine ounce from 1865 to 1916, inclusive, has been as follows:

*Price of silver per fine ounce, 1865–1916.*[2]

| | | | | | |
|---|---|---|---|---|---|
| 1865 | $1.337 | 1883 | $1.11 | 1900 | $0.62 |
| 1866 | 1.339 | 1884 | 1.11 | 1901 | .60 |
| 1867 | 1.33 | 1885 | 1.07 | 1902 | .53 |
| 1868 | 1.326 | 1886 | .99 | 1903 | .54 |
| 1869 | 1.325 | 1887 | .98 | 1904 | .58 |
| 1870 | 1.328 | 1888 | .94 | 1905 | .61 |
| 1871 | 1.325 | 1889 | .94 | 1906 | .68 |
| 1872 | 1.322 | 1890 | 1.05 | 1907 | .66 |
| 1873 | 1.297 | 1891 | 0.99 | 1908 | .53 |
| 1874 | 1.278 | 1892 | .87 | 1909 | .52 |
| 1875 | 1.24 | 1893 | .78 | 1910 | .54 |
| 1876 | 1.16 | 1894 | .63 | 1911 | .53 |
| 1877 | 1.20 | 1895 | .65 | 1912 | .615 |
| 1878 | 1.15 | 1896 | .68 | 1913 | .604 |
| 1879 | 1.12 | 1897 | .60 | 1914 | .553 |
| 1880 | 1.15 | 1898 | .59 | 1915 | .519 |
| 1881 | 1.13 | 1899 | .60 | 1916 | .658 |
| 1882 | 1.14 | | | | |

## PRODUCTION OF GOLD AND SILVER SINCE 1792.

According to tables published by the Director of the Mint the total production of gold and silver in the United States is as follows:

*Gold and silver produced in the United States, 1792–1916.*

[The estimate for 1792–1872 is by R. W. Raymond, commissioner, and for the period since 1872 by the Director of the Mint.]

| Period. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Commercial value. |
| 1792–1847 | 1,187,170 | $21,537,000 | 309,500 | $404,500 |
| 1848–1872 | 58,279,778 | 1,204,750,000 | 118,568,200 | 157,749,900 |
| 1873–1916 | 125,759,137 | 2,599,670,200 | 2,188,919,377 | 1,677,781,200 |
| | 185 226 085 | 3,828,957,200 | 2,307,797,077 | 1,835,935,600 |

[1] Report of Director of the Mint, p. 254, 1916. This represents average official quotations for sale by the Mint and is above dealers' prices for silver 0.999 fine.
[2] Based on London price of bar silver 1.000 fine, and taken at average price and par of exchange.

These figures show a total production of gold for the United States, from the earliest mining to the end of 1916, of 185,226,085 ounces, valued at nearly $3,829,000,000, and an output of silver of nearly 2,307,800,000 ounces, valued at nearly $1,836,000,000. Although the production of gold was less than one-twelfth the output of silver in quantity, its value was more than twice that of the silver.

The average commercial value per fine ounce of silver for the 124 years contributing to the total domestic production was a little less than $0.80. Fluctuations in value of silver per fine ounce are shown in the curve on figure 8. It is of interest to note that the average value for the total output of silver was reached in 1893. For the years shown (1871 to 1916, inclusive) the average annual value was above $0.80 before 1893 and has been below that figure every year since.

*Gold and silver produced in the United States, 1880–1916.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Commercial value. |
| 1880 | 1,741,500 | $36,000,000 | 30,318,700 | $34,717,000 |
| 1881 | 1,678,612 | 34,700,000 | 33,257,800 | 37,657,500 |
| 1882 | 1,572,187 | 32,500,000 | 36,196,900 | 41,105,900 |
| 1883 | 1,451,250 | 30,000,000 | 35,732,800 | 39,618,400 |
| 1884 | 1,489,950 | 30,800,000 | 37,743,800 | 41,921,300 |
| 1885 | 1,538,373 | 31,801,000 | 39,909,400 | 42,503,500 |
| 1886 | 1,686,788 | 34,869,000 | 39,694,000 | 39,482,400 |
| 1887 | 1,603,049 | 33,136,000 | 41,721,600 | 40,887,200 |
| 1888 | 1,604,478 | 33,167,500 | 45,792,700 | 43,045,100 |
| 1889 | 1,594,775 | 32,967,000 | 50,094,500 | 46,338,400 |
| 1890 | 1,588,877 | 32,845,000 | 54,516,300 | 57,242,100 |
| 1891 | 1,604,840 | 33,175,000 | 58,330,000 | 57,630,000 |
| 1892 | 1,597,098 | 33,015,000 | 63,500,000 | 55,662,500 |
| 1893 | 1,739,323 | 35,955,000 | 60,000,000 | 46,800,000 |
| 1894 | 1,910,813 | 39,500,000 | 49,500,000 | 31,422,100 |
| 1895 | 2,254,760 | 46,610,000 | 55,727,000 | 36,445,500 |
| 1896 | 2,568,132 | 53,088,000 | 58,834,800 | 39,654,600 |
| 1897 | 2,774,985 | 57,363,000 | 53,860,000 | 32,316,000 |
| 1898 | 3,118,398 | 64,463,000 | 54,438,000 | 32,118,400 |
| 1899 | 3,437,210 | 71,053,400 | 54,764,500 | 32,858,700 |
| 1900 | 3,829,897 | 79,191,000 | 57,647,000 | 35,741,100 |
| 1901 | 3,805,500 | 78,666,700 | 55,214,000 | 33,128,400 |
| 1902 | 3,870,000 | 80,000,000 | 55,500,000 | 29,415,000 |
| 1903 | 3,560,000 | 73,591,700 | 54,300,000 | 29,322,000 |
| 1904 | 3,892,480 | 80,464,700 | 57,682,800 | 33,456,000 |
| 1905 | 4,265,742 | 88,180,700 | 56,101,600 | 34,222,000 |
| 1906 | 4,565,333 | 94,373,800 | 56,517,900 | 38,256,400 |
| 1907 | 4,374,827 | 90,435,700 | 56,514,700 | 37,299,700 |
| 1908 | 4,574,340 | 94,560,000 | 52,440,800 | 28,050,600 |
| 1909 | 4,821,701 | 99,673,400 | 54,721,500 | 28,455,200 |
| 1910 | 4,657,018 | 96,269,100 | 57,137,900 | 30,954,500 |
| 1911 | 4,687,053 | 96,890,000 | 60,399,400 | 32,615,700 |
| 1912 | 4,520,717 | 93,451,500 | 63,766,800 | 39,197,500 |
| 1913 | 4,299,783 | 88,884,400 | 66,801,500 | 40,348,100 |
| 1914 | 4,572,976 | 94,531,800 | 72,455,100 | 40,067,700 |
| 1915 | 4,887,602 | 101,035,700 | 74,961,075 | 37,397,300 |
| 1916 | 4,479,056 | 92,590,300 | 74,414,802 | 48,953,000 |
| | 112,219,373 | 2,319,778,400 | 1,980,509,677 | 1,426,706,800 |

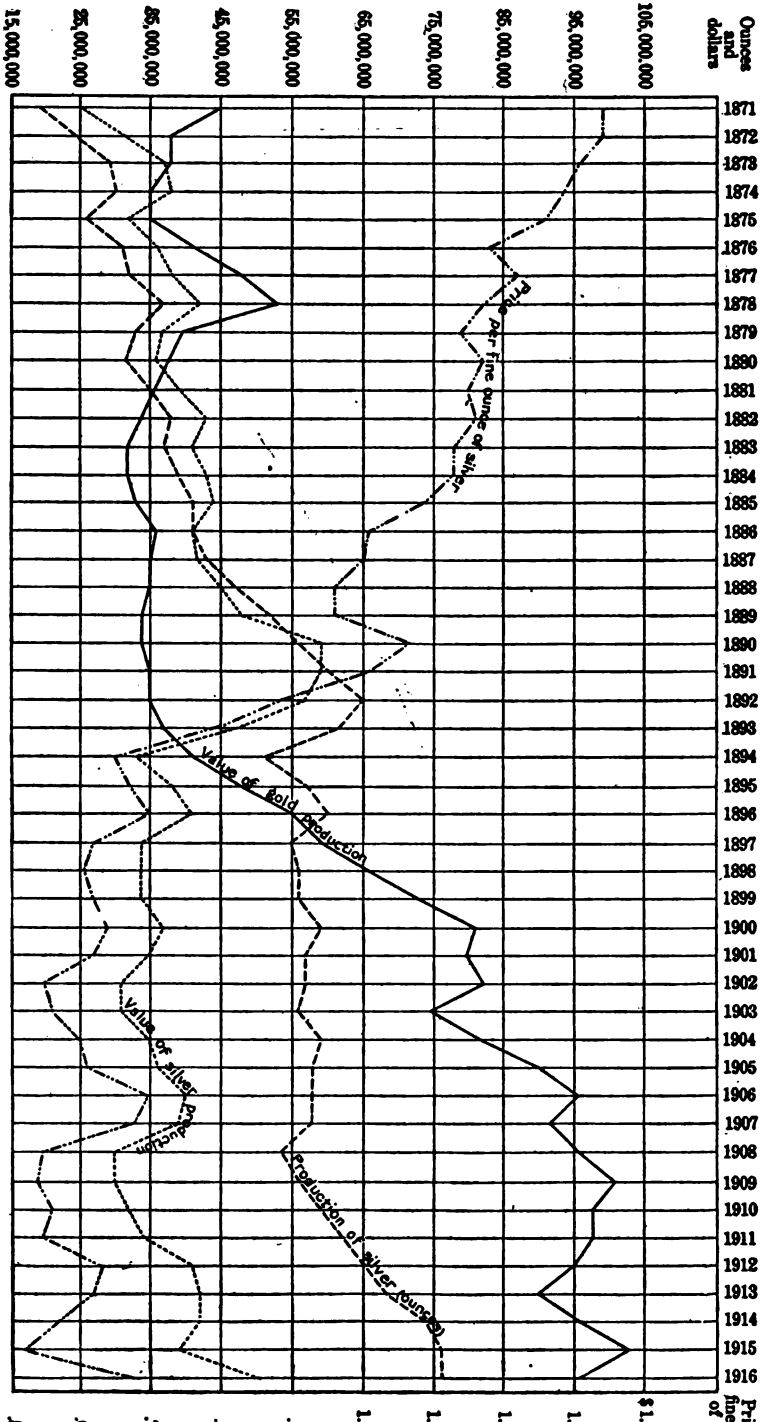



FIGURE 8.—Curves showing production and value of gold and silver and price per fine ounce of silver in the United States, 1871–1916.

## IMPORTS AND EXPORTS.

*Value of gold and silver imported and exported, 1916.*

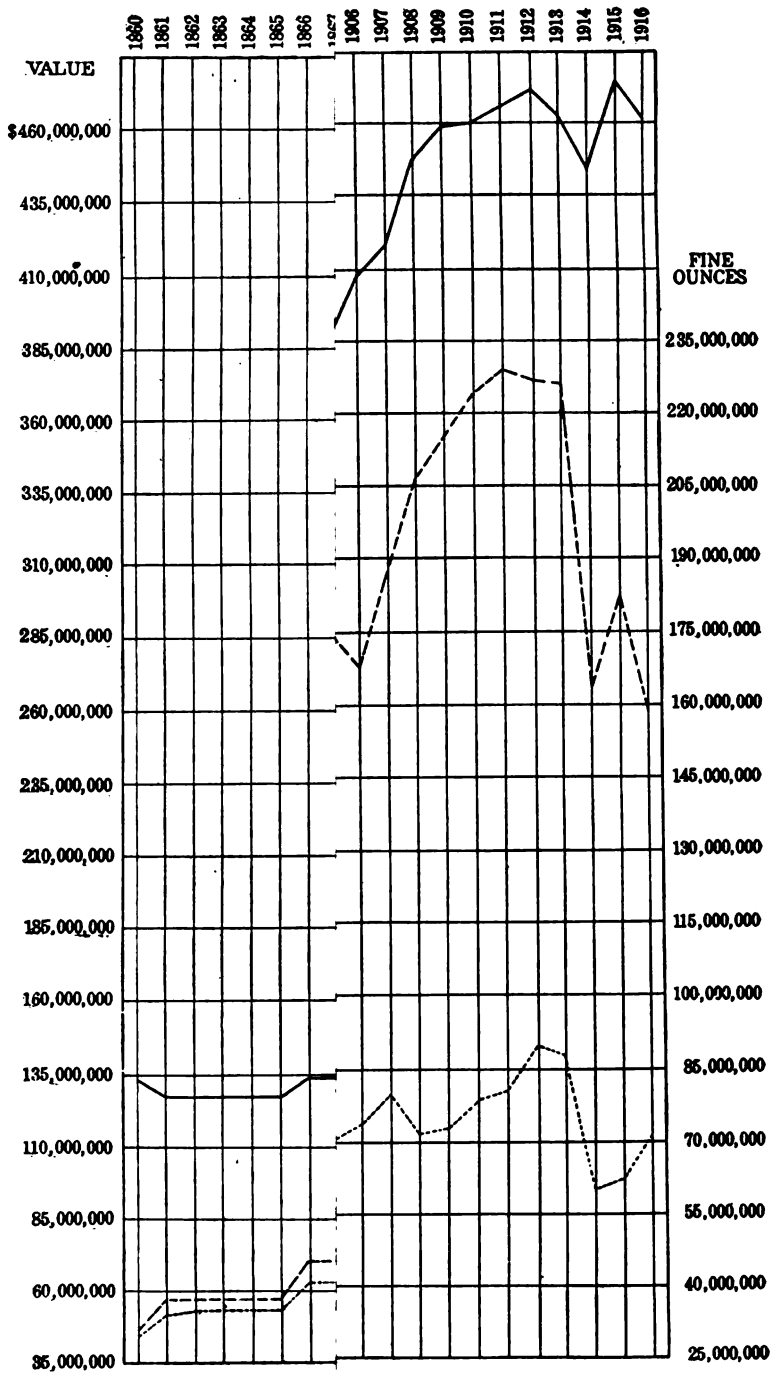
[Figures furnished by the Bureau of Foreign and Domestic Commerce.]

| Metal. | Imports. | Exports. | Excess of— | |
|---|---|---|---|---|
| | | | Imports. | Exports. |
| GOLD. | | | | |
| Contained in domestic ore and base bullion | | $308,168 | | $308,168 |
| Contained in foreign ore and base bullion | $13,402,002 | | $13,402,002 | |
| Domestic bullion refined | | 27,671,406 | | 27,671,406 |
| Foreign bullion refined | 514,425,434 | 24,288 | 514,401,146 | |
| United States coin | 3,128,455 | 106,903,188 | | 103,774,733 |
| Foreign coin | 155,034,343 | 20,885,877 | 134,148,466 | |
| | 685,990,234 | 155,792,927 | 661,951,614 | 131,754,307 |
| Excess | | | 530,197,307 | |
| SILVER. | | | | |
| Contained in domestic ore and base bullion | | 44,758 | | 44,758 |
| Contained in foreign ore and base bullion | 18,648,104 | | 18,648,104 | |
| Domestic bullion refined | | 64,558,849 | | 64,558,849 |
| Foreign bullion refined | 11,461,411 | 2,414,350 | 9,047,061 | |
| United States coin | 896,498 | 382,030 | 514,468 | |
| Foreign coin | 1,257,276 | 3,195,050 | | 1,937,774 |
| | 32,263,289 | 70,595,037 | 28,209,633 | 66,541,381 |
| Excess | | | | 38,331,748 |

## DOMESTIC SUPPLY.

The remarkable gain in domestic supply of gold indicated by the great excess of $530,200,000 in imports over exports for 1916, or $73,000,000 more than the world's total output of new gold for the year, was due to the fact that this country has been a creditor nation since the last great movements of its gold abroad. The continuation of large exports of silver to the Far East, and especially to the entente nations in Europe, was due largely to demand for exchange and for the coinage of silver money for troops in the field.

The domestic supply of new gold comes chiefly from dry or siliceous gold ores, treated in gold mills by amalgamation or cyanidation, or both, and from placer gravels largely by dredging. As shown on page 707 these ores and placer gravels supplied 88 per cent of the yield of gold in 1916. Examples of gold-milling ores are those of the Homestake mines of South Dakota, the Goldfield mines in Nevada, the Grass Valley and Mother Lode mines of California, the Alaska mines of the Juneau district, and the Cripple Creek and upper San Miguel County mines in Colorado. The great gold-dredging fields of California, especially of the Marysville district, are examples of the placer gravels as worked on a large scale. A considerable output of gold is also now recovered from the refining of copper bullion from copper ores, especially of the West Mountain or Bingham district, Utah, the Robinson or Ely district, Nev., and the Summit Valley or Butte district, Mont. In 1916 the copper ores of the United States produced more than 9 per cent of the total gold, against 7.2 per cent in 1915. The natural tendency is for the proportionate output from gold ores to decrease, with declining yield


1860
1861
1862
1863
1864
1865
1866
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
VALUE
$460,000,000
435,000,000
410,000,000
385,000,000
360,000,000
335,000,000
310,000,000
285,000,000
260,000,000
235,000,000
210,000,000
185,000,000
160,000,000
135,000,000
110,000,000
85,000,000
60,000,000
35,000,000
FINE OUNCES
235,000,000
220,000,000
205,000,000
190,000,000
175,000,000
160,000,000
145,000,000
130,000,000
115,000,000
100,000,000
85,000,000
70,000,000
55,000,000
40,000,000
25,000,000

from some of the principal gold camps, and for that from copper ores to increase—with a general net falling off of total yield of gold owing to the preponderant output from gold and gold-silver ores.

The principal domestic supply of new silver comes from dry or siliceous silver and silver-gold ores, from copper ores, from lead ores, and from lead-zinc ores—in the proportion of 31.2, 31.1, 24.4, and 10.9 per cent, respectively, in 1916, against 35.5, 26, 27, and 9 per cent, respectively, in 1915. The dry or siliceous silver-gold ores have come chiefly from four large mines of the Tonopah district, Nev., and declining output from this camp more than offsets gains from such ores elsewhere. The bulk of the silver ores of this class are milled and cyanided at or near the mines, although a smaller quantity of richer ores is shipped to copper and lead smelters. The largest single producer of silver in 1916 from domestic mines was the Anaconda Copper Co., of Montana, producing from copper ores, and the second largest was the Hercules Mining Co., of Idaho, producing from lead ores. Of the 21 mines or groups of mines producing silver on the largest scale, 6 were silver-gold and silver mines, 6 were copper mines, 8 were lead mines, and 1 was a zinc-lead mine. With large recent increases in output of argentiferous copper, lead, and zinc-lead ores, the domestic silver output has been maintained against decline from silver-gold and the (rare) silver ores. The silver obtained as a by-product from copper, lead, and zinc ores is derived from refining the copper and lead bullion produced in smelting those and other ores.

## WORLD'S PRODUCTION OF GOLD.

*Value of gold produced in the world, 1860–1916.*

[The annual production from 1860 to 1872 is obtained from statistics for 5-year periods compiled by Dr. Adolph Soetbeer. Since 1872 the estimates are those of the Bureau of the Mint.]

| Calendar year. | Value. | Calendar year. | Value. | Calendar year. | Value. | Calendar year. | Value. |
|---|---|---|---|---|---|---|---|
| 1860..... | $134,063,000 | 1875..... | $97,500,000 | 1890..... | $118,848,700 | 1905..... | $380,288,700 |
| 1861..... | 122,989,000 | 1876..... | 103,700,000 | 1891..... | 130,650,000 | 1906..... | 402,508,000 |
| 1862..... | 122,989,000 | 1877..... | 113,947,300 | 1892..... | 146,651,500 | 1907..... | 412,966,600 |
| 1863..... | 122,989,000 | 1878..... | 119,092,800 | 1893..... | 157,494,900 | 1908..... | 442,476,900 |
| 1864..... | 122,989,000 | 1879..... | 108,778,800 | 1894..... | 181,175,600 | 1909..... | 454,059,100 |
| 1865..... | 122,989,000 | 1880..... | 106,436,800 | 1895..... | 198,763,600 | 1910..... | 455,239,100 |
| 1866..... | 129,614,000 | 1881..... | 103,023,100 | 1896..... | 202,251,600 | 1911..... | 461,939,700 |
| 1867..... | 129,614,000 | 1882..... | 101,996,600 | 1897..... | 236,083,700 | 1912..... | 466,136,100 |
| 1868..... | 129,614,000 | 1883..... | 95,392,000 | 1898..... | 286,879,700 | 1913..... | 460,497,204 |
| 1869..... | 129,614,000 | 1884..... | 101,729,600 | 1899..... | 306,724,100 | 1914..... | 439,029,702 |
| 1870..... | 129,614,000 | 1885..... | 108,435,600 | 1900..... | 254,576,300 | 1915..... | 468,724,918 |
| 1871..... | 115,577,000 | 1886..... | 106,163,900 | 1901..... | 260,992,900 | 1916..... | 457,006,045 |
| 1872..... | 115,577,000 | 1887..... | 105,774,900 | 1902..... | 296,737,600 | | |
| 1873..... | 96,200,000 | 1888..... | 110,196,900 | 1903..... | 327,702,700 | | 12,174,636,469 |
| 1874..... | 90,750,000 | 1889..... | 123,489,200 | 1904..... | 347,377,300 | | |

The peak of the world's production of gold was reached in 1915 (see Pl. I), when all the great gold fields were contributing maximum outputs. Since then declines in the United States, Russia, and Australasia have more than offset increase in Africa.

The high-water mark of silver output was reached in 1911, when Mexico, Canada, and Australasia were all producing at or near the maximum. Increased output from the United States has not offset large falling off in the above-named countries, especially Mexico, in the last six years.

A valuable paper on "Gold and silver deposits in North and South America" was read by Waldemar Lindgren at the Second Pan American Scientific Congress and has been republished in the Transactions of the American Institute of Mining Engineers, volume 55, pages 883–909, 1917.

In the following table is shown the output of gold, by countries, as given by the Bureau of the Mint:

*World's production of gold, 1904–1916.*

| Country. | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 |
|---|---|---|---|---|---|---|
| North America: | | | | | | |
| United States | $80,464,700 | $88,180,700 | $94,373,800 | $90,435,700 | $94,560,000 | $99,673,400 |
| Canada | 16,462,500 | 14,610,400 | 12,023,900 | 8,382,800 | 9,482,100 | 9,382,200 |
| Mexico | 12,606,300 | 16,107,100 | 18,584,700 | 18,681,100 | 22,371,200 | 23,842,900 |
| Africa | 85,913,900 | 113,254,700 | 135,358,000 | 151,984,100 | 166,520,500 | 170,988,600 |
| Australasia | 87,767,300 | 85,926,500 | 82,391,400 | 75,677,700 | 73,327,300 | 71,007,900 |
| Europe: | | | | | | |
| Russia and Finland | 24,803,200 | 22,292,200 | 19,496,500 | 26,684,300 | 28,052,200 | 32,381,300 |
| Austria-Hungary | 2,117,300 | 2,457,400 | 2,615,400 | 2,484,900 | 2,469,300 | 1,942,000 |
| Germany | 64,700 | 66,700 | 80,400 | 66,600 | 64,800 | 69,000 |
| Norway | | | | | | |
| Sweden | 40,200 | 36,700 | 13,300 | 18,700 | 14,500 | 10,100 |
| Italy | 44,000 | 44,000 | 41,200 | 39,600 | 46,500 | 24,200 |
| Spain and Portugal | | | | | | 2,900 |
| Turkey | 29,000 | 6,000 | 6,000 | 4,500 | 2,200 | 500 |
| France | | | 502,400 | 835,400 | 1,147,400 | 1,400,000 |
| Great Britain | 359,800 | 112,700 | 29,200 | 29,200 | 16,000 | 21,500 |
| Serbia | | | 59,800 | 59,800 | 59,800 | 150,300 |
| South America: | | | | | | |
| Argentina | 9,200 | 5,500 | 5,500 | 103,000 | 161,300 | 189,900 |
| Bolivia | 21,900 | 18,800 | 754,600 | 1,267,400 | 346,300 | 492,400 |
| Chile | 636,900 | 948,500 | | | | |
| Colombia | 1,974,400 | 2,584,600 | 2,190,800 | 3,255,600 | 3,427,300 | 3,179,900 |
| Ecuador | 132,900 | 188,500 | 294,200 | 267,100 | 350,300 | 274,400 |
| Brazil | 2,043,500 | 2,044,600 | 2,403,000 | 2,020,700 | 2,196,600 | 2,252,900 |
| Venezuela | 300,000 | 171,400 | 25,300 | 22,400 | 24,500 | 280,600 |
| Guiana— | | | | | | |
| British | 1,608,800 | 1,690,700 | 1,607,700 | 1,304,400 | 1,408,100 | 1,192,700 |
| Dutch | 441,600 | 632,500 | 689,200 | 640,000 | 663,000 | 621,000 |
| French | 1,806,400 | 1,859,700 | 1,858,900 | 2,360,800 | 2,135,500 | 2,143,800 |
| Peru | 1,329,200 | 516,100 | 829,000 | 514,500 | 514,500 | 514,500 |
| Uruguay | 25,000 | 50,000 | 31,700 | 51,900 | 91,600 | 91,600 |
| Central America | 1,252,500 | 1,513,400 | 1,910,700 | 2,107,800 | 3,018,800 | 2,680,100 |
| Asia: | | | | | | |
| Japan | 2,948,200 | 3,072,400 | 2,748,900 | 2,773,000 | 3,321,600 | 3,616,900 |
| China | 4,500,000 | 4,500,000 | 4,500,000 | 4,500,000 | 8,647,300 | 9,352,100 |
| Indo-China | | | | 31,800 | 65,600 | 65,600 |
| Chosen (Korea) | 3,000,000 | 2,593,000 | 2,283,000 | 2,170,800 | 3,047,500 | 1,993,600 |
| Siam | 51,800 | 48,600 | 53,200 | 166,200 | 327,600 | 327,600 |
| India, British | 11,722,900 | 11,950,200 | 12,087,700 | 10,383,600 | 10,598,500 | 10,358,600 |
| East Indies, British | 1,485,300 | 1,391,000 | 1,448,700 | 1,561,300 | 1,400,900 | 1,436,900 |
| East Indies, Dutch | 1,414,500 | 1,414,500 | 1,254,900 | 2,079,900 | 2,596,300 | 2,146,400 |
| | 347,377,200 | 380,288,700 | 402,503,000 | 412,966,600 | 442,476,900 | 454,059,100 |

| Country. | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| North America: | | | | | | | |
| United States | $96,269,100 | $96,890,000 | $93,451,500 | $88,884,400 | $94,531,800 | $101,035,700 | $92,590,300 |
| Canada | 10,205,800 | 9,762,100 | 12,648,806 | 16,598,900 | 15,963,004 | 18,977,901 | 19,234,976 |
| Mexico | 24,910,600 | 24,880,100 | 24,500,000 | 19,308,800 | 4,788,175 | 6,559,275 | 7,690,707 |
| Cuba | | 20,000 | | | | | |
| Africa | 175,189,900 | 191,538,400 | 211,850,600 | 207,326,500 | 201,996,796 | 217,851,898 | 221,457,639 |
| Australasia | 65,470,600 | 60,184,200 | 54,509,400 | 53,113,200 | 47,569,023 | 48,988,177 | 40,408,755 |
| Europe: | | | | | | | |
| Russia and Finland | 35,579,600 | 32,151,600 | 22,199,000 | 26,508,700 | 28,596,392 | 26,322,746 | 26,322,746 |
| Austria-Hungary | 2,172,600 | 2,155,100 | 2,043,200 | 2,179,300 | 200,744 | 1,392,465 | 1,392,465 |
| Germany | 62,900 | 78,100 | 78,100 | 135,600 | | | |
| Norway | 1,400 | | | | | | |
| Sweden | 2,000 | 2,000 | 20,300 | 17,600 | 54,304 | 25,323 | 25,323 |
| Italy | 29,600 | 44,800 | 11,000 | 17,200 | 32,145 | 2,295 | 2,295 |
| Spain and Portugal | 2,800 | 2,400 | 2,300 | 2,300 | 2,336 | 661 | 661 |
| Turkey | 500 | 500 | 500 | 500 | 475 | 475 | |
| France | 1,707,100 | 1,812,100 | 1,812,100 | 2,127,400 | 1,400,000 | 1,400,000 | 1,000,000 |
| Great Britain | 39,600 | 39,600 | 27,800 | 17,900 | 20,238 | 19,266 | 19,142 |
| Serbia | | 251,100 | 251,100 | 328,000 | 116,000 | | |

*World's production of gold, 1904–1916*—Continued.

| Country. | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| South America: | | | | | | | |
| Argentina | $173,100 | $289,000 | $107,300 | $2,600 | | | $6,330 |
| Bolivia and Chile | 463,600 | 362,500 | 175,000 | 336,884 | $202,770 | $814,418 | 396,922 |
| Colombia | 3,370,000 | 3,167,800 | 2,971,700 | 2,971,700 | 4,678,587 | 5,453,148 | 6,173,867 |
| Ecuador | 249,200 | 276,800 | 406,500 | 406,500 | 346,853 | 545,674 | 545,674 |
| Brazil | 1,954,700 | 3,834,500 | 3,570,600 | 2,254,700 | 2,139,803 | 2,424,515 | 2,424,515 |
| Venezuela | 340,500 | 364,800 | 623,500 | 419,040 | 564,220 | 1,395,349 | 1,424,930 |
| Guiana— | | | | | | | |
| British | 1,192,700 | 892,000 | 879,800 | 1,353,500 | 1,126,500 | 923,892 | 767,525 |
| Dutch | 792,600 | 523,400 | 407,300 | 470,400 | 503,400 | 449,054 | 438,223 |
| French | 2,229,100 | 2,229,100 | 3,050,600 | 3,050,600 | 1,959,793 | 1,959,793 | 1,959,793 |
| Peru | 455,900 | 492,300 | 492,200 | 912,280 | 1,022,125 | 1,109,891 | 1,179,537 |
| Uruguay | 91,600 | 70,600 | 111,000 | 29,900 | 15,276 | 11,836 | 11,836 |
| Central America | 4,657,400 | 3,360,400 | 3,030,400 | 2,721,700 | 2,393,190 | 2,970,271 | 3,517,597 |
| Asia: | | | | | | | |
| Japan | 3,903,600 | 4,118,600 | 4,467,000 | 3,614,400 | 4,679,358 | 5,386,066 | 5,386,066 |
| China | 3,658,100 | 3,314,600 | 3,658,900 | 3,658,900 | 3,658,900 | 2,804,692 | 2,804,692 |
| Indo-China | 55,000 | 74,700 | 74,700 | 74,700 | 66,419 | 43,659 | 65,620 |
| Chosen (Korea) | 4,399,100 | 2,889,400 | 2,852,600 | 3,582,500 | 3,309,870 | 3,739,477 | 4,122,351 |
| Siam | 56,500 | 56,500 | 56,500 | 56,500 | | | |
| India, British | 10,718,400 | 11,054,100 | 11,055,700 | 12,178,000 | 11,378,400 | 11,522,457 | 11,206,509 |
| East Indies, British | 1,446,800 | 1,339,400 | 1,352,000 | 1,352,000 | 4,480,853 | 3,100,000 | 3,100,000 |
| East Indies, Dutch | 3,387,100 | 3,387,100 | 3,387,100 | 3,387,100 | | | |
| Federated Malay States | | | | 282,400 | 269,147 | 351,527 | 327,871 |
| Formosa | | | | 814,600 | 952,806 | 1,143,017 | 1,001,178 |
| | 455,239,100 | 461,939,700 | 466,136,100 | 460,497,204 | 439,029,702 | 468,724,918 | 457,006,045 |

For some foreign countries, owing to the difficulty of obtaining accurate statistics since the beginning of the European war, estimates have been made for 1914, 1915, and 1916; for a few other countries, because of lack of basis for estimates, the figures for preceding years have been repeated.

The figures given for the years 1904 to 1912, inclusive, are taken from the reports of the Director of the Mint. The statistics for 1913 to 1916, inclusive, were mainly adjusted in conference between the Mint and the Geological Survey, but some small changes in the statistics for a few countries in South America have been made since the Mint figures were published.

The notable increase of total world's output of gold culminated in a new record of $468,724,918 in 1915.

The estimated world's production of gold in 1916 was $457,000,000, or about $11,700,000 less than in 1915. There were small increases in Canada, Mexico, and South Africa, which were more than offset by considerable decreases in Australia and the United States.

The present tendency, in the absence of discovery and development of new gold fields on a large scale, is toward a declining world's output of new gold.

## WORLD'S PRODUCTION OF SILVER.

*Production of silver in the world, 1860–1916.*

[The annual production from 1860 to 1872 is obtained from statistics for 5-year periods compiled by Dr. Adolph Soetbeer. For the period since 1872 the estimates are those of the Bureau of the Mint.]

| Year. | Quantity (fine ounces). | Commercial value. | Year. | Quantity (fine ounces). | Commercial value. |
|---|---|---|---|---|---|
| 1860 | 29,095,428 | $39,337,000 | 1890 | 126,095,062 | $131,937,000 |
| 1861 | 35,401,972 | 46,191,000 | 1891 | 137,170,000 | 135,500,200 |
| 1862 | 35,401,972 | 47,651,000 | 1892 | 153,151,782 | 133,404,400 |
| 1863 | 35,401,972 | 47,616,000 | 1893 | 165,472,621 | 129,119,900 |
| 1864 | 35,401,972 | 47,616,000 | 1894 | 164,610,394 | 104,493,000 |
| 1865 | 35,401,972 | 47,368,000 | 1895 | 167,500,960 | 109,545,600 |
| 1866 | 43,051,583 | 57,646,000 | 1896 | 157,061,370 | 105,859,300 |
| 1867 | 43,051,583 | 57,173,000 | 1897 | 160,421,082 | 96,252,700 |
| 1868 | 43,051,583 | 57,086,000 | 1898 | 169,055,253 | 99,742,600 |
| 1869 | 43,051,583 | 57,043,000 | 1899 | 168,337,452 | 101,002,600 |
| 1870 | 43,051,583 | 57,173,000 | 1900 | 173,591,364 | 107,626,400 |
| 1871 | 63,317,014 | 83,958,000 | 1901 | 173,011,283 | 103,806,700 |
| 1872 | 63,317,014 | 83,705,000 | 1902 | 162,763,483 | 86,264,700 |
| 1873 | 63,267,187 | 82,120,800 | 1903 | 167,689,322 | 90,552,200 |
| 1874 | 55,300,781 | 70,674,400 | 1904 | 164,195,266 | 95,233,300 |
| 1875 | 62,261,719 | 77,578,100 | 1905 | 172,317,688 | 105,113,700 |
| 1876 | 67,753,125 | 78,322,600 | 1906 | 165,054,497 | 111,721,100 |
| 1877 | 62,679,916 | 75,278,600 | 1907 | 184,206,984 | 121,577,100 |
| 1878 | 73,385,451 | 84,540,000 | 1908 | 203,131,404 | 108,655,100 |
| 1879 | 74,383,495 | 83,532,700 | 1909 | 212,149,023 | 110,364,400 |
| 1880 | 74,795,273 | 85,640,600 | 1910 | 221,715,673 | 119,727,000 |
| 1881 | 79,020,872 | 89,925,700 | 1911 | 226,192,923 | 122,143,800 |
| 1882 | 86,472,091 | 98,232,300 | 1912 | 224,310,654 | 137,983,800 |
| 1883 | 89,175,023 | 98,984,300 | 1913 | [a] 225,410,085 | [a] 136,153,754 |
| 1884 | 81,567,801 | 90,785,000 | 1914 | 160,626,019 | 88,845,464 |
| 1885 | 91,609,959 | 97,518,800 | 1915 | 178,850,500 | 92,809,100 |
| 1886 | 93,297,290 | 92,793,500 | 1916 | 156,626,531 | 107,519,408 |
| 1887 | 96,123,586 | 94,031,000 | | | |
| 1888 | 108,827,606 | 102,185,900 | | 6,668,850,662 | 5,236,975,726 |
| 1889 | 120,213,611 | 112,414,100 | | | |

[a] Changes made in Mint figures for Bolivia, Chile, and Peru are based on later information.

*World's production of silver, 1905–1916, in fine ounces.*

[Figures supplied by U. S. Bureau of the Mint.]

| Country. | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North America: | | | | | | | | | | | | |
| United States | 56,101,600 | 56,517,900 | 56,514,700 | 52,440,800 | 54,721,500 | 57,137,900 | 60,399,400 | 63,766,800 | 66,801,500 | 72,455,100 | 74,961,075 | 74,414,802 |
| Canada | 5,994,292 | 8,568,665 | 12,779,800 | 22,106,233 | 27,529,473 | 32,869,264 | 32,740,748 | 31,625,451 | 31,524,708 | 28,406,711 | 26,625,960 | 25,459,741 |
| Mexico | 65,040,865 | 55,225,268 | 61,147,203 | 73,664,027 | 73,942,432 | 71,372,194 | 79,032,440 | 74,640,300 | 70,703,828 | 27,546,752 | 39,570,151 | 22,838,385 |
| Central American States | 1,361,449 | 1,670,159 | 1,892,896 | 1,460,809 | 2,294,272 | 2,026,885 | 1,211,747 | 2,845,954 | 2,135,641 | 2,754,868 | 2,920,496 | 2,602,471 |
| South America: | | | | | | | | | | | | |
| Bolivia and Chile | 3,494,851 | 3,149,395 | 5,222,358 | 5,806,117 | 5,548,154 | 6,490,163 | 4,555,043 | 4,049,856 | 3,932,594 | 789,685 | 3,870,065 | 2,052,149 |
| Argentina | 150,149 | 14,440 | 25,178 | 127,108 | 265,106 | 263,255 | 203,111 | 81,996 | 35,271 | | | 12,037 |
| Brazil | | | | | | | 47,222 | 40,610 | 28,364 | 76,685 | 21,523 | 21,523 |
| Colombia | 679,245 | 763,335 | 1,048,719 | 1,375,039 | 431,204 | 866,093 | 817,431 | 587,683 | 587,683 | 351,271 | 351,271 | 309,415 |
| Ecuador | | 13,592 | 2,456 | 22,642 | 22,642 | 22,642 | 22,642 | 22,642 | 22,642 | 16,726 | 24,655 | 24,655 |
| Peru | 6,156,044 | 7,404,238 | 9,566,118 | 9,566,118 | 9,566,118 | 6,626,930 | 8,351,563 | 8,351,563 | 9,971,067 | 9,214,190 | 9,419,950 | 9,419,950 |
| Guiana and Uruguay | | | | | | | | 724,235 | 51,111 | | | 93 |
| Venezuela | | | | 104,626 | 204,958 | 208,043 | 436,903 | 122,303 | | | | |
| Europe: | | | | | | | | | | | | |
| Austria-Hungary | 1,860,169 | 1,806,322 | 1,744,233 | 1,770,457 | 999,184 | 1,540,808 | 1,538,772 | 1,840,297 | 2,104,107 | 1,572,746 | 1,772,699 | 1,772,699 |
| Germany | 5,820,947 | 5,696,433 | 5,088,086 | 4,971,544 | 5,332,901 | 5,597,026 | 4,984,677 | 4,984,677 | 4,984,677 | | | |
| France | 890,555 | 719,453 | 794,973 | 592,042 | 629,848 | 713,028 | 429,831 | 429,831 | 520,766 | | | |
| Great Britain | 167,479 | 137,216 | 137,216 | 135,255 | 141,943 | 136,370 | 136,370 | 113,769 | 128,543 | 135,458 | 96,450 | 96,450 |
| Greece | 829,025 | 829,025 | 829,025 | 829,025 | 829,025 | 881,539 | 803,750 | 803,750 | 803,750 | 591,464 | 591,464 | 591,464 |
| Italy | 757,777 | 672,449 | 737,843 | 674,848 | 786,620 | 468,566 | 998,576 | 447,761 | 423,888 | 510,365 | 493,856 | 486,462 |
| Norway | 242,805 | 175,475 | 201,516 | 226,175 | 213,122 | 229,989 | 292,075 | 247,988 | 247,988 | 440,917 | 413,867 | 413,867 |
| Spain and Portugal | 4,000,000 | 4,064,532 | 4,097,035 | 4,175,674 | 4,767,091 | 4,546,430 | 4,270,324 | 5,358,448 | 4,437,637 | 4,434,417 | 4,567,454 | 4,567,454 |
| Russia | 204,960 | 166,183 | 132,122 | 132,122 | 132,122 | 140,632 | 477,140 | 200,094 | | | 638,403 | 638,403 |
| Serbia | | | | | 11,226 | | 24,132 | 24,132 | 28,758 | 12,014 | | |
| Sweden | 24,765 | 32,375 | 29,761 | 35,728 | 29,373 | 19,823 | 19,823 | 32,202 | 58,969 | 33,511 | 24,230 | 24,230 |
| Turkey | 37,874 | 37,874 | 67,351 | 7,971 | 1,717,896 | 1,717,896 | 1,717,896 | 1,509,133 | 1,509,133 | 1,509,133 | 1,509,133 | |
| Australasia | 15,035,486 | 13,909,371 | 17,949,099 | 17,175,099 | 16,359,284 | 21,545,828 | 16,578,421 | 14,737,944 | 18,128,577 | 3,573,077 | 4,295,755 | 3,863,418 |
| Asia: | | | | | | | | | | | | |
| British India | | | | | | 44,772 | 104,323 | 93,649 | | 236,440 | 284,875 | 628,656 |
| China | | | | | | | | | | | 18,230 | 18,230 |
| Chosen | | | | | | 164,844 | 9,446 | 12,224 | 15,048 | 16,864 | 21,897 | 24,979 |
| Dutch East Indies | 182,889 | 248,240 | 335,454 | 571,953 | 465,980 | 465,980 | 465,980 | 465,980 | 465,980 | | | |
| Indo-China | | | | | | | | | | 1,767 | 1,056 | 1,056 |
| Formosa | | | | | | | | | 51,763 | 51,080 | 47,653 | 47,653 |
| Japan | 2,664,842 | 2,530,093 | 3,073,411 | 3,887,397 | 4,130,972 | 4,581,613 | 4,459,087 | 4,932,852 | 4,649,910 | 4,836,228 | 5,120,293 | 5,120,293 |
| Africa | 619,620 | 702,464 | 790,431 | 1,272,595 | 1,076,577 | 1,037,160 | 1,064,050 | | | | | |
| Belgian Kongo | | | | | | | | | 1,454 | 4,770 | 4,770 | 4,770 |
| Egypt | | | | | | | | | | 1,223 | 1,657 | 1,657 |
| French East Africa | | | | | | | | 73,286 | | | | |
| Madagascar | | | | | | | | | | | | |
| Rhodesia | | | | | | | | 158,572 | 121,537 | 150,794 | 185,233 | 200,676 |
| Transvaal, Cape Colony, Natal | | | | | | | | 984,672 | 933,191 | 901,763 | 996,379 | 968,883 |
| | 172,317,688 | 165,054,497 | 184,206,984 | 203,131,402 | 212,149,023 | 221,715,673 | 226,192,923 | 224,310,654 | 225,410,085 | 160,626,019 | 178,850,500 | 156,626,521 |

The figures for the world's production of silver in 1916 show that the United States and Canada produced about 100,000,000 ounces, or 64 per cent, and that Mexico, Central America, and South America yielded more than 37,000,000 ounces, so that approximately only 20,000,000 ounces of silver came from all other countries.

### GOLD AND SILVER AND THE WAR.

Financing on a vaster scale than ever before demands larger annual supplies of new gold to preserve national credits; yet decreasing tenor and quantity of ore in many gold fields, decreasing labor in some, and increasing costs in most of them are combined with the fixed value of gold to limit the necessary profits and development that are required for maintaining the world's production of gold even at the present rate.

War demands for silver, because of continued needs in the Orient and because of large increase in silver coinage both to protect gold currency and avoid excessive paper money and also for convenience in payment of vast armed forces, have greatly increased. These demands follow, on the one hand, upon the largely increased commercial use in recent years of silver nitrate in the enormously enlarged moving-picture industry and, on the other hand, upon the marked falling off in the world's production of silver, especially in the normal output from Mexico. The copper and lead mines of North America and particularly of South America are adding each year more largely to their contributions of by-product silver, but their output can not, in all likelihood, indefinitely offset the declining production from the silver and silver-gold ores, as a study of the tables of this report for the United States would seem to demonstrate.

Increased costs of mining, shortage of labor and equipment, and decline of production from gold and gold-silver ores combine to force the attention of financiers upon the precious-metal situation with a view to adopting measures that may be necessary to stimulate output and conserve all available supplies. It is well known that any given producing ore deposit is a diminishing asset and that new ore bodies, as well as improved technique in mining and metallurgy, are essential to assure continuance of output. Few new ore bodies of importance have been added to the gold and silver producers in recent years, and it may well prove that the high-water mark of production has been passed and that the world is facing a decline in output of both gold and silver. It is unwise, however, at this time to predict that important new discoveries will not be made.

The concentration of efforts to produce munitions of war for present use and to produce materials for reconstruction after the war may force the precious-metals industry into the background, but the industry can not be long neglected without consequences as evident as they may prove disastrous to national welfare. Renewal of order and prosperity in Mexico should go far to increase the supply of silver and would materially add to the world's output of gold.

## MINES REPORT.

### METHOD OF COLLECTING STATISTICS.

The first table in this report presents the final official figures of the production of gold and silver in the United States in 1916 as agreed upon by the Bureau of the Mint and the United States Geo-

logical Survey. With the comparatively unimportant exceptions of domestic gold and silver contained in ores and mattes exported for reduction during the year, these figures record the actual production of gold and silver bullion from domestic ores in marketable form as metals, either refined or unrefined.

Owing to the difficulty of tracing this total gold and silver production back to its origin by States, counties, and mining districts, however, the Geological Survey attacks this problem of distribution by systematic investigation of the mine production of ores containing gold and silver during the calendar year and of the output of the placer mines. In this way the state of the mining industry is studied in detail, and classification of output by methods of production and by kinds of ore, as well as by mining districts, is obtained. The resulting figures form the basis of the mines report.

Of the two plans outlined for ascertaining the gold and silver production of the United States it may be said that the one is a measure of the mining industry and the other a measure of the metallurgical industry; that the one reports the production and recoverable content of mine output and the other the metal actually recovered in marketable form. The two methods will not produce exactly corresponding results, nor should they be expected to do so.

The figures of the reports of the Mint and of the mines reports for a period of years sufficiently long to compensate for overlap or lag should agree within allowable limits of error due to the complex problem involved.

For the last 12 years in which complete statistics have been gathered by both methods the final figures have been as follows:

*Production of gold and silver in the United States, 1905–1916, according to mint and to mine returns.*

| Year. | Mint. | | Mine. | |
|---|---|---|---|---|
| | Gold. | Silver. | Gold. | Silver. |
| | | *Ounces.* | | *Ounces.* |
| 1905 | $88,180,700 | 56,101,900 | $88,159,881 | 56,272,496 |
| 1906 | 94,373,800 | 58,517,900 | 97,219,645 | 57,362,455 |
| 1907 | 90,435,700 | 56,514,700 | 87,471,136 | 52,500,104 |
| 1908 | 94,560,000 | 52,440,900 | 91,914,891 | 50,878,140 |
| 1909 | 99,673,400 | 54,721,500 | 99,438,144 | 57,315,677 |
| 1910 | 96,269,100 | 57,137,900 | 94,933,778 | 57,598,509 |
| 1911 | 96,890,000 | 60,399,400 | 97,054,791 | 61,108,791 |
| 1912 | 93,451,500 | 63,766,800 | 92,880,467 | 66,041,506 |
| 1913 | 88,884,400 | 66,801,500 | 89,987,888 | 71,200,237 |
| 1914 | 94,531,900 | 72,455,100 | 92,703,757 | 69,633,769 |
| 1915 | 101,035,700 | 74,961,075 | 99,605,314 | 72,368,878 |
| 1916 | 92,590,300 | 74,414,802 | 92,822,430 | 78,875,176 |
| | 1,130,876,400 | 746,233,077 | 1,124,192,122 | 751,155,738 |

These figures show, according to Mint reports, a total excess of gold for the 12 years of $6,684,278, or a difference of not quite 0.6 per cent, and a total deficit of silver of only 4,922,661 ounces, or a difference less than 0.66 per cent. The figures for Alaska placers are not considered to be so closely approximate as the above agreement for gold, hence the differences for the United States proper are probably even lower. It is thought that those small differences are fully accounted for in the detailed discussions of the subject in pre-

vious reports of this series. For figures of any one year an excess of mining over smelting and refining is indicated by larger returns in the mines reports for gold or silver or both and opposite relations or excess of smelting and refining and drawing upon stocks are indicated by larger returns in the Mint report.

## UNITS OF MEASUREMENT.

In measurement of ores and concentrates the short ton of 2,000 pounds is used throughout. The price of gold is fixed by law at $20.67+ per fine ounce. The annual average prices for silver from 1865 to 1916, inclusive, based on the equivalent New York value of a fine ounce with exchange at par, are given elsewhere in this report. (See p. 681.) The average commercial prices (or dealers' prices) for silver 0.999 fine at New York are those quoted from day to day on the market and run uniformly somewhat below the prices as given elsewhere by years.

## PRODUCTION OF GOLD AND SILVER REPORTED FROM THE MINES.

The following table gives the quantity and value of the output of recoverable gold and silver (mine production) by States reported from the producing mines in 1916 to the United States Geological Survey. The increase or decrease of production shows results by comparison with the corresponding Survey mine figures for 1915.

*Mine production of gold and silver in the United States in 1916.*

| State or Territory. | Gold. | | Silver. | | Increase or decrease. | |
|---|---|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. | Gold. | Silver (fine ounces). |
| Alabama | 418.44 | $8,650 | 53 | $35 | + $3,407 | + 41 |
| Alaska | 834,067.86 | 17,241,713 | 1,379,171 | 907,495 | + 539,569 | + 307,389 |
| Arizona | 192,801.41 | 3,985,559 | 7,212,039 | 4,745,522 | − 180,466 | + 1,563,019 |
| California | 1,035,744.59 | 21,410,741 | 2,564,354 | 1,687,345 | −1,031,555 | + 885,508 |
| Colorado | 926,566.09 | 19,153,821 | 7,656,544 | 5,038,006 | −3,261,123 | + 628,572 |
| Georgia | 1,090.32 | 22,539 | 74 | 49 | − 13,282 | − 64 |
| Idaho | 53,977.30 | 1,115,810 | 12,300,873 | 8,093,974 | − 63,921 | + 531,745 |
| Illinois | ..... | ..... | 5,684 | 3,740 | ..... | + 1,820 |
| Maryland, New Hampshire, Pennsylvania, and Vermont | ..... | ..... | 4,021 | 2,646 | ..... | + 3,642 |
| Michigan | ..... | ..... | 716,640 | 471,549 | ..... | + 130,707 |
| Missouri | ..... | ..... | 129,450 | 85,178 | ..... | + 71,694 |
| Montana | 220,130.15 | 4,550,494 | 16,494,366 | 10,853,293 | − 453,701 | + 2,115,929 |
| Nevada | 428,904.21 | 8,866,237 | 13,837,525 | 9,105,092 | −2,538,063 | − 622,315 |
| New Mexico | 66,877.47 | 1,382,480 | 1,766,274 | 1,162,208 | − 78,625 | − 239,257 |
| North Carolina | 1,269.22 | 26,237 | 663 | 436 | − 145,764 | − 802 |
| Oklahoma | ..... | ..... | 606 | 399 | ..... | + 606 |
| Oregon | 92,017.91 | 1,902,179 | 231,342 | 152,223 | + 40,383 | + 113,395 |
| Philippines | 73,249.44 | 1,514,200 | 17,643 | 11,609 | + 193,300 | + 2,495 |
| Porto Rico | 29.03 | 600 | ..... | ..... | − 100 | ..... |
| South Carolina | 15.48 | 320 | 28 | 18 | − 3,469 | + 20 |
| South Dakota | 360,908.65 | 7,460,644 | 215,205 | 141,605 | + 54,339 | + 15,341 |
| Tennessee | 277.63 | 5,739 | 94,701 | 62,313 | − 1,123 | − 5,842 |
| Texas | 20.03 | 414 | 653,455 | 429,973 | − 1,089 | − 22,018 |
| Utah | 172,938.06 | 3,574,947 | 13,253,037 | 8,720,498 | − 34,162 | + 939,832 |
| Virginia | 42.81 | 885 | 783 | 515 | + 351 | + 783 |
| Washington | 27,944.06 | 577,655 | 335,121 | 220,510 | + 186,236 | + 79,294 |
| Wyoming | 994.88 | 20,566 | 5,524 | 3,035 | + 5,974 | + 4,684 |
| | 4,490,285.04 | 92,822,430 | 78,875,176 | 51,899,866 | −6,782,884 | + 6,506,298 |
| Increase or decrease in value | ..... | ..... | ..... | ..... | −6,782,884 | +$15,208,846 |

A decrease in production of gold from mines of the United States of $6,782,884 is shown for 1916, following an increase of $6,901,557 in 1915. An increase of 6,506,298 ounces of silver is shown, following an increase of 2,735,109 ounces in 1915.

The principal gold-producing States ranked as follows in 1916: California, Colorado, Alaska, Nevada, and South Dakota, and these five States together made nearly 80 per cent of the total output. The only notable increases were in Alaska and Washington. The most notable decreases in gold were $3,261,123 in Colorado, $2,538,063 in Nevada, and $1,031,555 in California.

The principal silver-producing States in 1916 in order of output were Montana, Nevada, Utah, Idaho, Colorado, and Arizona, and these six States together produced 90 per cent of the total for the United States. The largest increases for 1916 were 2,115,929 ounces in Montana, 1,563,019 ounces in Arizona, 939,832 ounces in Utah, 885,598 ounces in California, 628,572 ounces in Colorado, and 531,745 ounces in Idaho. Large decreases of silver were 622,315 ounces in Nevada, and 239,257 ounces in New Mexico.

About $28,000,000, or 30 per cent, of the entire output of gold in the United States in 1916 was produced by 18 companies. The largest producer was the celebrated Homestake mine in South Dakota. Thirteen of the larger properties produced the gold from dry or siliceous ores, 2 produced it from gravels by dredging, and 3 recovered the gold in the treatment of copper ores. Deducting the output of gold of the large producing operators, it is shown that about $65,000,000 came from the operation of about 4,600 placer and deep mines, many of which produced between $100,000 and $600,000 each. Hundreds of mines, especially placer properties in California, Oregon, Idaho, Alaska, Arizona, and the Appalachian States, yielded very small quantities of gold.

*Larger producers of gold in the United States in 1916, in order of output.*

| Operator. | State. | Mining district. | Source of gold. |
|---|---|---|---|
| Homestake Mining Co. | South Dakota. | Whitewood | Dry or siliceous ores. |
| Yuba Consolidated Goldfields | California | Marysville | Dredging gravels. |
| Goldfield Consolidated Mines Co. | Nevada | Goldfield | Dry or siliceous ores. |
| Empire Mines | California | Grass Valley | Do. |
| Alaska Gastineau Mining Co. | Alaska | Juneau | Do. |
| Cresson Consolidated Mining Co. | Colorado | Cripple Creek | Do. |
| Portland Gold Mining Co. | do | do | Do. |
| Vindicator Consolidated Gold Mining Co | do | do | Do. |
| Alaska Treadwell Mining Co. | Alaska | Juneau | Do. |
| North Star Mines | California | Grass Valley | Do. |
| Yukon Gold Co. | Alaska | Iditarod and Ruby | Dredging gravels. |
| Alaska United Mining Co. | do | Juneau | Do. |
| Utah Copper Co. | Utah | West Mountain | Copper ores. |
| Kennedy Mining Co. | California | Jackson | Dry or siliceous ores. |
| Liberty Bell Gold Mining Co. | Colorado | Upper San Miguel | Do. |
| Tomboy Gold Mines Co. | do | do | Do. |
| Nevada Consolidated Copper Co. | Nevada | Robinson (Ely) | Copper ores. |
| Anaconda Copper Co. | Montana | Summit Valley(Butte) | Do. |

The largest output of silver was that of the Anaconda Copper Co. in the treatment of copper ores. The first four producing properties each derived the silver from different kinds of ore. Six of the 21 mines enumerated recovered silver from copper ore, 8 from lead ore, 6 from dry or siliceous ore, and 1 from zinc ore. Several mines yielded more silver than the Presidio mine, but it was the largest producer

of silver from ore that contained no appreciable quantity of any other metal. The approximate output of the 21 properties was 39,000,000 ounces, or about 50 per cent of the total production of silver in the United States in 1916.

*Larger producers of silver in the United States in 1916, in order of output.*

| Operator. | State. | Mining district. | Source of silver. |
|---|---|---|---|
| Anaconda Copper Co. | Montana | Summit Valley (Butte) | Copper ores. |
| Hercules Mining Co. | Idaho | Leland | Lead ores. |
| Tonopah-Belmont Development Co. | Nevada | Tonopah | Dry or siliceous ores. |
| Butte & Superior Mining Co. | Montana | Summit Valley (Butte) | Zinc-lead ores. |
| Tonopah Extension Mining Co. | Nevada | Tonopah | Dry or siliceous ores. |
| Chief Consolidated Mining Co. | Utah | Tintic | Lead ores. |
| Tonopah Mining Co. | Nevada | Tonopah | Dry or siliceous ores. |
| Bunker Hill & Sullivan Mining Co. | Idaho | Yreka | Lead ores. |
| Caledonia Mining Co. | do. | do. | Do. |
| Federal Mining & Smelting Co. | do. | Hunter | Do. |
| United Verde Copper Co. | Arizona | Verde | Copper ores. |
| North Butte Mining Co. | Montana | Summit Valley | Do. |
| Silver King Coalition Mining Co. | Utah | Uintah | Lead ores. |
| Calumet & Arizona Mining Co. | Arizona | Warren | Copper ores. |
| Hecla Mining Co. | Idaho | Leland | Lead ores. |
| Greenhill Cleveland Mining Co. | do. | do. | Do. |
| Kennecott Copper Co. | Alaska | Kennecott | Copper ores. |
| Copper Queen Consolidated Mining Co. | Arizona | Warren | Do. |
| Jim Butler Tonopah Mining Co. | Nevada | Tonopah | Dry or siliceous ores. |
| Nevada Wonder Mining Co. | do. | Wonder | Do. |
| Presidio Mining Co. | Texas | Shafter | Siliceous (silver) ores. |

## MINE PRODUCTION OF GOLD AND SILVER BY STATES.

### ALASKA.

It is estimated by A. H. Brooks that the total production of gold in Alaska from earliest mining, in 1880, to the end of 1916 has been $278,100,656, of which $197,332,992 has come from placers. The total production of silver has been 6,302,459 fine ounces, of which 3,567,308 ounces was recovered from copper ores and 1,636,823 ounces from the refining of placer gold.[1]

*Gold.*—The mine production of gold in Alaska in 1916 was $17,241,713, or nearly $540,000 more than that of 1915. The yield from siliceous ores decreased from $6,069,023 in 1915 to $5,912,736 in 1916; the yield from copper ores increased from $153,121 in 1915 to $188,977 in 1916; the placer output in 1916 was $11,140,000, against $10,480,000 in 1915. Thirty-four dredges produced $2,679,000 of the placer gold, which was $349,000 more than the yield from dredging in 1915.

Of the productive gold lode mines 8 were in southeastern Alaska, 5 on Prince William Sound, 7 in Kenai Peninsula, 4 in Willow Creek district, and 8 in Fairbanks district. The 13 deep gold mines in southeastern Alaska yielded nearly 90 per cent of the gold derived from siliceous ores.

The 3,548,798 tons of siliceous ores treated in 1916 yielded $1.70 in gold and silver a ton, and the 617,264 tons of copper ore contained $1.59 in gold and silver a ton and had a copper content of 9.70 per cent.

About 36 per cent of the total gold output of Alaska came from lode mines in 1916, against 38 per cent in 1915, 32 per cent in 1914,

[1] U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 173, 1917.

31.6 per cent in 1913, and 29 per cent in 1912, indicating an accelerating transition from placer to lode mining. The 650 placers operated in 1916 yielded approximately 7,100,000 cubic yards of auriferous gravel, of which the dredges handled about 3,900,000 cubic yards and made an average recovery of 69 cents a yard in 1916, against 51 cents a yard in 1915, and 52 cents a yard in 1914. The estimated total recovery of gold by dredging for the period 1903–1916, inclusive, is $15,109,894.

The only new placer-bearing area discovered in 1916 was in the Tolstoi Creek basin in the southern part of the Innoko district.

*Silver.*—The mine production of silver in Alaska in 1916 was 1,379,171 fine ounces, against 1,071,782 ounces in 1915. The copper mines produced 1,207,121 ounces, an increase of 309,282 ounces. The siliceous ores yielded 110,050 ounces in 1916, against 91,341 ounces in 1915, 28,254 ounces in 1914, and the placers 62,000 ounces in 1916, against 82,602 ounces in 1915.

### ARIZONA.

*Gold.*—The mine production of gold in Arizona in 1916 was $3,985,559, which was $180,466 less than in 1915. Placers contributed only $14,281, most of which came from small mines in Yuma and Yavapai counties. The deep mines produced $3,971,278, of which 38 per cent came from dry or siliceous ores mined chiefly in Mohave, Yavapai, and Cochise counties, and 55 per cent was contained in copper ores mined chiefly in Cochise and Yavapai counties. Mohave County had a gold output of $1,038,814, Cochise County $1,512,878, and Yavapai County $1,035,351. The gold recovered from ores treated at gold and silver mills represented 36 per cent of the total output and crude ores shipped to smelters contained nearly 53 per cent. The crude copper ores mined and smelted directly (without previous concentration) contained an average gold content of 53 cents a ton.

*Silver.*—The mine production of silver increased from 5,649,020 fine ounces in 1915 to 7,212,039 ounces in 1916. Of this production 5,347,893 ounces came from copper ores, 997,372 ounces from dry or siliceous ores, 539,108 ounces from lead ores, 159,247 ounces from lead-zinc ores, and smaller quantities from zinc, copper-zinc, and copper-lead ores. Cochise County produced 3,709,225 ounces in 1916, of which 2,478,568 ounces came from copper ores and 776,279 ounces from siliceous ores. The silver output of Yavapai County, which increased from 1,343,363 ounces in 1915 to 1,735,302 ounces in 1916, was mainly derived from copper ores. Bullion recovered from gold and silver ores, almost all by cyanidation, yielded 658,830 ounces of silver. Concentrates contained 1,179,552 ounces and crude ore shipped to smelters contained 5,305,608 ounces, or more than 73 per cent of the total output of silver.

### CALIFORNIA.

*Gold.*—The mine production of gold in California in 1916 was $21,410,741. The decreased yield of $1,031,555 was due to a smaller production from deep-mining operations.

In 1916 the deep mines produced $12,835,084 (a decrease of $998,595), of which gold-quartz ores yielded 92.5 per cent and copper

ores 7.2 per cent. California placers in 1916 yielded $8,575,657 in gold, or $32,960 less than in 1915. Of the placer production $390,015 was recovered by hydraulic mining, $251,297 by drift mining, $165,118 by sluicing, and $7,769,227 by dredging. The total dredge production from 1898 to the end of 1916 has been $86,873,458 and the yield of gold by dredges was equal to 36 per cent of the total yield of gold for 1916. The Yuba County dredges, 13 in number, made the largest output of gold, the value being $3,140,150, an increase of $464,060. Sacramento County, with 13 dredges working, made an output of $1,829,478, a decrease of $300,309. In Butte County (including Oroville and other districts) 14 dredges produced $1,210,874 in gold, or $280,192 less than in 1915. Dredges were also operated in Calaveras, Eldorado, Merced, Stanislaus, Placer, Shasta, Siskiyou, and Trinity counties.

Six of the 28 counties in California which reported mine production of gold had a yield of more than $1,000,000 in 1916, as follows: Nevada, $3,669,878; Amador, $3,660,550; Yuba, $3,167,723; Sacramento, $1,833,855; Calaveras, $1,356,120; Butte, $1,257,231. Of these, Yuba, Sacramento, and Butte counties obtained most of their yield by dredging, Amador and Calaveras are on the Mother Lode, and the Nevada County production was mainly from siliceous ores of the Grass Valley district. The five Mother Lode counties—Amador, Calaveras, Eldorado, Mariposa, and Tuolumne—whose output is mainly gold milling ores, produced $3,719,649 in gold from mill bullion and $2,092,169 from concentrates in 1916, against a recovery of $4,059,435 from mill bullion and $2,249,989 from concentrates in 1915.

*Silver.*—The mine production of silver in California in 1916 was 2,564,354 fine ounces, an increase of 885,598 ounces. More than 65 per cent of the output, or 1,679,455 ounces, came from the copper ores of Shasta County. Copper ores from Calaveras, Placer, Plumas, and other counties yielded 290,328 ounces. Zinc ores yielded 60,293 ounces, siliceous ores 171,600 ounces, silver-lead ores 323,339 ounces, and silver ores, lead ores, and placers the remainder. The only counties producing more than 100,000 ounces of silver in 1916 were Shasta, Inyo, Calaveras, and San Bernardino. About 90 per cent of all the silver was recovered from crude ores sent to smelters.

## COLORADO.

*Gold.*—The total mine production of gold in Colorado in 1916 was $19,153,821, a decrease of $3,261,123. The Cripple Creek district, with a decrease of $1,563,944, produced $12,119,550 in gold, which was 63 per cent of the State output of gold from all sources. During 1916 the Roosevelt tunnel was driven 2,311 feet. The total length of the tunnel from portal to breast at the end of 1916 was 22,000 feet.

The San Juan region, in Dolores, La Plata, Ouray, San Juan, and San Miguel counties, produced $3,041,275, a decrease of $813,246. Lake County yielded $1,720,440, a decrease of $525,712, and there were also decreases in Boulder, Clear Creek, Gunnison, Gilpin, La Plata, Ouray, Chaffee, and San Juan counties. Siliceous and dry ores, which amounted to 76 per cent of all the ore sold or treated, yielded 92 per cent of the total output of gold. Slightly more than

2 per cent came from lead ore, 4 per cent from placers, and about 1 per cent from copper ore, and the remainder from other classes of ore. The placer production in 1916 was $712,924, an increase of $19,614. Summit County produced nearly 81 per cent and Lake County 17 per cent of the placer gold. More than 99 per cent of the placer gold from these two counties was recovered by dredges.

*Silver.*—The mine production of silver in Colorado in 1916 was 7,656,544 fine ounces, an increase of 628,572 ounces. Lake County, principally Leadville, produced 2,931,281 ounces, an increase of 360,279 ounces. San Miguel County produced 812,041 ounces, a decrease of 284,600. There was a considerably larger production of silver from Ouray and Pitkin counties and decreased outputs from Chaffee, Dolores, San Miguel, and La Plata counties. Siliceous and dry ores yielded 73 per cent of of the silver received, lead ores 15 per cent, lead-zinc ores 7 per cent, and copper ores 3 per cent. The remainder came from placers, zinc ores, and copper-lead ores.

### IDAHO.

*Gold.*—The mine production of gold in Idaho in 1916 was $1,115,810, a decrease of $63,921. The total production of gold from Idaho from the discovery of placer gold in 1863 to the end of 1916 is estimated at $130,106,160 by C. N. Gerry.[1]

Boise and Elmore counties were the largest producers of gold, yielding about 60 per cent of the total output. The lode mines produced gold valued at $666,717. The placer mines produced $449,093 in gold in 1916, of which $327,696, or 73 per cent, was won by dredging. The total output of gold recovered by dredges from 1897 to the end of 1916 has been $3,722,056. Of the total gold in 1916 about 40 per cent came from placers, 47 per cent from siliceous ores, 7 per cent from copper ores, and the remainder from lead and lead-zinc ores.

*Silver.*—The mine production of silver in Idaho in 1916 was 12,300,873 fine ounces, or 531,745 ounces more than in 1915. The total yield of silver from Idaho for the period 1863 to 1916, inclusive, is 212,676,617 fine ounces.[1]

There was an increase of 4 per cent in the silver output from Shoshone County, which yielded 95 per cent of the total quantity of silver in 1915 and in 1916, against 98 per cent in 1914. Lead ores contained 66.5 per cent of the output of silver and lead-zinc ores 30 per cent. Crude ore shipped, which averaged 16.22 ounces of silver a ton, supplied nearly 32 per cent of the silver, and concentrates, which averaged 21.53 ounces of silver a ton, contained more than 67 per cent of the total silver. Inability to handle and smelt all the ores mined had the effect of curtailing the production of silver.

### MARYLAND, PENNSYLVANIA, NEW HAMPSHIRE, AND VERMONT.

There was only a small production of silver reported by copper mines in Frederick County, Md., in 1916, although work was done on prospects in Montgomery County, Md., and copper-bearing concentrates continued to be shipped from the Cornwall magnetite mines at Lebanon, Pa.

[1] U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 565, 1917.

There was no active mining in New Hampshire, but some concentrates containing silver, lead, and zinc were recovered from old tailings at the Silver Lake mines in Carroll County.

The Pike Hill and Bicknell mines in Orange County, Vt., shipped considerable ore carrying copper and silver.

### MICHIGAN.

*Silver.*—The copper mines of Michigan produced 716,640 fine ounces of silver in 1916, against 585,933 ounces in 1915. The silver was mainly derived from the electrolytic treatment of 63,635,475 pounds of copper. The average recovery of silver per ton of "rock" treated was 0.33 ounce a ton. Of the total output of silver 562,295 ounces came from mines in Houghton County.

### MISSOURI, OKLAHOMA, ILLINOIS, AND KENTUCKY.

*Silver.*—The lead and zinc mines of the Central States produce no gold and only a comparatively small quantity of silver. Nearly all the silver is a by-product from the refining of lead from concentrates of lead ores mined in southeastern Missouri. The total yield of silver from Missouri in 1916 was 129,450 fine ounces, which, with the exception of a few ounces recovered from copper ore, was derived from lead recovered from 88,081 tons of galena concentrates. The average recovery was slightly less than 1.5 ounces of silver per ton of concentrates smelted.

The lead-zinc fluorspar deposits of the Kentucky-Illinois field carry silver, and from the lead concentrates shipped from Illinois in 1916 a recovery of 5,684 ounces was recorded, against 3,864 ounces in 1915. The average silver content per ton recovered from lead concentrates from Illinois in 1916 was 6.50 ounces. The Criswell mine, near Byars, McClain County, Okla., shipped a small quantity of silver ore to Omaha for smelting.

### MONTANA.

*Gold.*—The mine production of gold in Montana decreased from $5,004,195 in 1915 to $4,550,494 in 1916. The placer yield was $723,159. The decrease in output was about equally divided between lode and placer mines. Silver Bow County had the largest output, $973,052. Most of the placer gold was recovered by one company, which operated four dredges in Alder Gulch in Madison County. Deer Lodge County produced $741,055, chiefly from siliceous ores, and Lewis and Clark County $758,114, also chiefly from siliceous ores. At amalgamation and cyanidation plants $1,247,096 in gold was produced, or an average recovery of $3.11 per ton of ore and tailings treated. Ore treated at concentration mills yielded concentrates containing $950,922, or 14 cents a ton, and crude ore shipped to smelters contained $1,625,414 in gold, or an average of $2.29 a ton.

*Silver.*—Montana mines produced 16,494,366 fine ounces of silver in 1916, a production nearly 13 per cent larger than that of 1915. The copper ores yielded 11,226,034 ounces (an average of 1.81 ounces per ton), of which Silver Bow County (Butte) supplied 11,115,755 ounces. The lead-zinc ores produced 2,759,410 ounces, of which Silver Bow County supplied 2,629,447 ounces and Mineral County

65,735 ounces. The dry or siliceous ores produced 1,175,791 ounces, of which Granite County supplied 582,845 ounces. Nearly all the silver from zinc ore, 1,008,141 ounces, came from Silver Bow County.

### NEVADA.

*Gold.*—The mine production of gold in Nevada in 1916 was $8,866,237, against $11,404,300 in 1915. The production in 1916 from mines in Esmeralda County was $2,684,688, a decrease of more than $2,000,000. The Goldfield district yielded $2,651,158 in gold in 1916, against $4,389,385 in 1915. Nye County produced $2,505,714, of which Tonopah yielded $1,941,441. The counties having a substantial increase in gold were Mineral, White Pine, Humboldt, Storey, Elko, and Clark. Eighty per cent of the decreased output of gold was caused by the smaller yield from Goldfield and Tonopah.

*Silver.*—There was a decrease in the production of silver in Nevada in 1916, the total production being 13,837,525 fine ounces, against 14,459,840 ounces in 1915. Nye County (almost wholly from the Tonopah district) again led in output with 8,868,267 ounces, which was about 1,400,000 ounces less than in 1915. Churchill County, with 1,386,524 ounces, Humboldt County, with 869,424 ounces, and Lincoln County, with 559,645 ounces, were the other counties which had an output exceeding 500,000 ounces. Dry or siliceous ores yielded all but 1,085,614 ounces of the output of silver and nearly 90 per cent of this yield was recovered by cyanidation.

### NEW MEXICO.

*Gold.*—The mine production of gold in New Mexico in 1916 was $1,382,480, against $1,461,105 in 1915 and $1,171,696 in 1914. Socorro County produced $375,125, which was almost entirely from siliceous ores of the Mogollon district; Grant County, $419,675; and Colfax County, $422,297.

Copper ores, chiefly from Grant County, contained $234,342, and dry and siliceous ores yielded $1,123,732. The output from other kinds of ore was very small, and the placer output was only $11,116.

*Silver.*—The mine production of silver in New Mexico decreased from 2,005,531 fine ounces in 1915 to 1,766,274 ounces in 1916. Socorro County produced 1,081,711 fine ounces, or 61 per cent, chiefly from siliceous ores from the Mogollon district, the remainder from mixed ores of the Magdalena district. The output of silver from Grant County increased from 508,552 fine ounces in 1915 to 549,907 ounces in 1916, and most of this yield came from the Lordsburg district. Dry and siliceous gold and silver ores, chiefly from Grant, Sandoval, and Socorro counties, yielded 81 per cent of the total; copper ores, chiefly from Grant, Socorro, and Santa Fe counties, yielded 13 per cent. The remainder of the production was from lead and copper-lead ores, mainly from the Central and Magdalena districts

### OREGON.

*Gold.*—The mine production of gold from Oregon increased 2 per cent, being $1,902,179 in 1916, against $1,861,796 in 1915. The output in 1916 was the largest recorded by the Survey for 13 years.

The increase was due entirely to the placer mines, which yielded $872,517, or $390,347 more in 1916 than in 1915. The output from deep mines was almost entirely from siliceous ores. The deep mines of the State produced $1,029,662, a decrease of $349,964. Of the placer output the hydraulic mines yielded $164,548, or $49,535 more than in 1915. The two dredges in the Cracker Creek district in Baker County and one dredge in Grant County produced $670,450, and a few drift mines and surface placers in Baker, Jackson, Crook, Josephine, and Malheur counties produced the remainder of the placer gold. Baker County, with a yield of $1,640,626, was the only county which produced more than $100,000 in gold.

*Silver.*—The mine production of silver in Oregon in 1916 was 231,342 fine ounces, a decrease of 113,395 ounces. Of the total production 118,143 ounces came from siliceous ores, 103,822 ounces from copper ores, and 128 ounces from lead ores.

## SOUTH DAKOTA.

The total value of the production of gold in South Dakota from 1876 to the end of 1916 is given by Charles W. Henderson, of the United States Geological Survey, as $200,154,589, and the total output of silver for the same period as 6,247,738 fine ounces.[1]

*Gold.*—The mine production of gold in South Dakota in 1916 was $7,460,644, against $7,406,305 in 1915. The output was almost wholly from siliceous milling ores of low grade, of which about 64 per cent was recovered by amalgamation and the remainder by cyanidation. The Homestake mines and mills were operated continuously and produced $6,531,003 in bullion from 1,600,220 tons of ore treated. The Golden Reward, Mogul, Reliance, Trojan, and Wasp No. 2 mills were also operated steadily. The small yield of placer gold came from Custer, Lawrence, and Pennington counties.

*Silver.*—The output of silver, derived mainly from refining the gold bullion produced, was 215,205 fine ounces, or 15,341 ounces more than in 1915.

## SOUTHERN APPALACHIAN STATES.

The total production of gold from 1799 to the end of 1916 in the southern Appalachian States, as shown from data compiled by the Bureau of the Mint and the United States Geological Survey, has been $50,978,188. The figures credit Alabama with $763,277, Georgia with $17,810,987, Maryland with $71,339, North Carolina with $23,614,595, South Carolina with $5,180,346, Tennessee with $242,818, and Virginia with $3,294,826.

*Gold.*—The combined mine production of gold in the southern Appalachian States in 1916 was $64,370, against $224,250 in 1915. North Carolina, with a yield of $26,237, had the largest production; Georgia followed with $22,539; Alabama, $8,650; Tennessee, $5,739; South Carolina, $320; and Virginia, $885. The gold produced in Tennessee was from copper ores of the Ducktown district. The gold production from 46 placer mines amounted to $16,616. Nearly all the remainder of the gold was from dry or siliceous ores.

[1] U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 270, 1917.

*Silver.*—The mine production of silver from the southern Appalachian States was 96,877 ounces in 1916, against 102,166 ounces in 1915. About 560 ounces came from siliceous ores and placers, 94,700 ounces from the Ducktown copper ores of Tennessee, and about 1,350 ounces from copper ores from Maryland and Virginia.

### TEXAS.

*Gold.*—The total output of gold from Texas mines from 1885 to the end of 1916 is given by Charles W. Henderson as $43,535.[1]

The gold yield has been very small and has been mainly a by-product. The output of gold decreased from $1,503 in 1915 to $414 in 1916.

*Silver.*—The total production of silver in Texas from 1885 to 1916, inclusive, has been 13,071,337 ounces, according to Henderson.[1]

The mine production for 1916 was 653,455 fine ounces, against 675,473 ounces in 1915. The greater part of the silver continued to come from the Presidio silver mine and cyanidation mill in the Shafter district, Presidio County.

### UTAH.

*Gold.*—The total output of gold in Utah from 1864 to 1916, inclusive, is given by V. C. Heikes, of the United States Geological Survey, as $89,764,177.[2] The output of gold decreased from $3,609,109 in 1915 to $3,574,947 in 1916. The largest part of the gold was contained in ores produced in Salt Lake County and amounted to $2,513,096. Juab County ranked next with $856,474, against $910,354 in 1915. The Bingham district, with its large output of copper and other ores, produced $2,490,158 in gold in 1916, and the Tintic district, partly in Juab County and partly in Utah County, produced $855,454. The placer gold production in 1916 was only $1,250, and the output recovered by cyanidation and amalgamation was less than $6,400. The greater part of the Utah gold (58 per cent) was derived from copper ores mainly mined in Salt Lake and Juab counties; lead and lead-zinc ores contained 36 per cent.

*Silver.*—The total output of silver in Utah from 1864 to 1916, inclusive, has been 352,541,394 fine ounces, according to Heikes.[2] The mine production of silver in Utah in 1916 was 13,253,037 ounces, an increase of 939,832 ounces. The largest production was from Juab County, credited with 4,892,439 ounces (mainly from lead ores), against 4,005,600 ounces in 1915. Salt Lake County had the next largest output, 3,863,264 ounces (from copper, lead, and lead-zinc ores), against 3,152,267 ounces in 1915. Of the Salt Lake County output of silver, the Bingham district produced 80 per cent. The Tintic district, in Juab and Utah counties, yielded 5,113,566 ounces (mainly from lead ores); and the Park City region, in Summit and Wasatch counties, produced 2,900,718 ounces, mainly derived from lead and lead-zinc ores. Altogether the lead ores of Utah yielded 8,118,264 ounces of silver in 1916, the copper ores 2,633,402 ounces,

[1] U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 211, 1917. [2] Idem, p. 421.

the lead-zinc ores 1,199,023 ounces, and the dry or siliceous ores 1,153,993 ounces. The crude ore smelted in 1916 contained 10,536,058 ounces and concentrates contained 2,473,132 ounces.

### WASHINGTON.

The total production of gold in Washington from earliest mining to the end of 1916 is given by C. N. Gerry, of the United States Geological Survey, as $26,956,368, and the total production of silver as 6,771,120 fine ounces.[1]

*Gold.*—The mine production of gold in Washington in 1916 was $577,655, against $391,419 in 1915. Of the production in 1916 more than 72 per cent was derived from ores shipped directly to smelters, 25.5 per cent came from ores treated by amalgamation or cyanidation, and less than 2 per cent came from placers. Siliceous ores supplied about 93 per cent of all gold recovered and copper ores about 2 per cent. Ferry County alone produced $399,376 in 1916, against $351,973 in 1915. Nearly all the yield from Ferry County was, as usual, from the Republic district.

*Silver.*—The mine production of silver in Washington increased from 255,837 ounces in 1915 to 335,121 ounces in 1916, of which Ferry County produced 138,293 ounces, mainly from siliceous ores, and Stevens County 174,612 ounces, mainly from copper ores.

### WYOMING.

The total production of gold in Wyoming from 1867 to the end of 1916 is given by Charles W. Henderson as $1,231,342 and the output of silver for the same period as 65,160 ounces.[2]

The mine production of gold in Wyoming in 1916 was $20,566, against $14,592 in 1915, and that of silver 5,524 ounces in 1916, against 840 ounces in 1915. The Seminole and Elk Mountain districts, in Carbon County, yielded $13,342 in gold and 617 ounces of silver, mainly from siliceous ores treated by amalgamation

### PHILIPPINE ISLANDS.

The output of gold in the Philippines from 1907 to 1916, inclusive, has been $6,351,361. The mine production of gold for 1916 was $1,514,200, against $1,320,900 in 1915, $1,371,514 in 1914, $868,362 in 1913, and $570,212 in 1912. The mine production of silver in the Philippines in 1916 was 17,643 ounces and was recovered entirely from gold bullion refined.

### NUMBER OF PRODUCING MINES.

The following table indicates the number of mines producing gold and silver in 1916 divided into placers and deep, or lode, mines. The placers are those in which the gold and the silver in natural alloy with the gold and, in a few placers, found also with platinum are recovered from gravels and sands, whether by hand washing, sluicing, hydraulicking, drifting (in frozen ground or ancient buried river channels), or by dredging. The deep mines are those producing gold and silver (from ores as distinguished from gravels) mainly from underground

[1] U. S. Geol. Survey Mineral Resources, 1916, pt. 1, p. 603, 1917. [2] Idem, p. 277.

workings, including those whose ores are valuable chiefly for copper, lead, or zinc, but which contribute precious metals as by-products. In addition to producing mines here enumerated, many properties were being prospected and developed without making any output in 1916, and many other mining claims were being held by assessment work only.

The enumeration of placer mines is less satisfactory than that of deep mines, because some of the operations are only temporary and individually small and because the production is frequently by transitory miners not regularly working placer ground. The unit, so far as possible is, however, as for deep mines, not the operator, but the mining claim or group of claims.

*Number of producing gold and silver mines in 1916.*[a]

| State or Territory. | Number of mines. | | | State or Territory. | Number of mines. | | |
|---|---|---|---|---|---|---|---|
| | Placer. | Deep. | Total. | | Placer. | Deep. | Total. |
| Alabama | 3 | 2 | 5 | North Carolina | 20 | 6 | 26 |
| Alaska | 650 | 47 | 697 | Oregon | 75 | 33 | 108 |
| Arizona | 23 | 504 | 527 | South Carolina | 3 | ..... | 3 |
| California | 292 | 297 | 589 | South Dakota | 16 | 29 | 45 |
| Colorado | 27 | 825 | 852 | Tennessee [c] | ..... | 2 | 2 |
| Georgia | 20 | 6 | 26 | Texas | ..... | 11 | 11 |
| Idaho | 162 | 256 | 418 | Utah | 8 | 310 | 318 |
| Illinois [b] | ..... | 2 | 2 | Vermont and New Hampshire | ..... | 3 | 3 |
| Maryland and Pennsylvania | ..... | 3 | 3 | Virginia [c] | ..... | 3 | 3 |
| Michigan [b] | ..... | 10 | 10 | Washington | 23 | 90 | 113 |
| Missouri and Oklahoma [b] | ..... | 4 | 4 | Wyoming | 4 | 24 | 28 |
| Montana | 120 | 393 | 513 | | 1,530 | 3,765 | 5,295 |
| Nevada | 65 | 714 | 779 | | | | |
| New Mexico | 19 | 191 | 210 | | | | |

[a] Philippines and Porto Rico not included.
[b] Number of mines contributing to silver production.
[c] Number of mines contributing to gold and silver production.

The table shows the number and distribution of mines producing gold and silver in the United States and Alaska. With the exception of (1) some of the Michigan copper mines, (2) all zinc mines in the Eastern and Central States and a few in the Far West, and (3) all lead mines of the Central States (except a few in Illinois and southeastern Missouri), practically all mines producing copper, lead, and zinc in the United States and Alaska produce gold and silver also. The table, therefore, with these exceptions, is a table of mines producing these five metals. It also includes certain mines producing oxidized manganese iron fluxing ores of Colorado, Utah, and elsewhere, whose ores contain small quantities of precious metals, especially silver, and are smelted as flux.

*Number of producing gold and silver mines, 1906–1916.*

| Year. | Placer. | Deep. | Total. | Year. | Placer. | Deep. | Total. |
|---|---|---|---|---|---|---|---|
| 1906 | 2,316 | 2,114 | 4,430 | 1913 | 1,774 | 3,502 | 5,276 |
| 1907 | 2,586 | 2,604 | 5,190 | 1914 | 1,815 | 3,158 | 4,973 |
| 1908 | 2,599 | 2,864 | 5,463 | 1915 | 1,720 | 3,597 | 5,317 |
| 1909 | 2,187 | 3,183 | 5,370 | 1916 | 1,530 | 3,765 | 5,295 |
| 1910 | 2,026 | 3,299 | 5,325 | | | | |
| 1911 | 2,146 | 3,553 | 5,699 | Average | 2,067 | 3,201 | 5,268 |
| 1912 | 2,044 | 3,567 | 5,611 | | | | |

Comparison of the figures for 1916 shows a net total decrease of 22 producing mines, following decreases in 1912, 1913, 1914, and an increase of 344 mines in 1915. The total number of properties operated in 1916 was 27 in excess of the average for the last 11 years. The number of placer properties worked in 1916 showed a decrease of 190 and was nearly 800 less than the number operated in 1906. This is a natural result due to the exhaustion of the rich gravels and to the acquisition of large areas of placer ground by dredge mining companies. The number of deep mines operated increased from 3,597 in 1915 to 3,765 in 1916, or 564 more than the average for 11 years. High prices for copper, lead, and zinc in 1916 resulted in more deep mines being operated than in any year for which data are available by the Survey.

In total number of operating mines Colorado again ranked first with 852, followed in order by Nevada with 779, Alaska with 697, California with 589, Arizona with 527, Montana with 513, and Idaho with 418. In number of placers Alaska lead with 650, followed by California with 292, and Idaho with 162; and in deep mines Colorado led with 825, followed by Nevada with 714, Arizona with 504, Montana with 393, Utah with 310, and California with 297.

### ORE PRODUCTION, CLASSIFICATION, AND AVERAGE VALUE.

The best index of deep mining is, of course, the quantity, metallic content, and value of ore mined, rather than the number of mines or of operators. In the next following table are given the production of ore by classes of ore and by States and Territories from mines producing gold and silver and the average extraction value of precious metals per ton.

The classification adopted is necessarily arbitrary in part. An ore is generally understood to be worked at a profit for one or more metals. The complex nature of western ores, especially, and the gradations from one well-recognized class to another render essential some fixed measures for the terminology used. The dry or siliceous ores comprise gold and silver ores proper, as well as fluxing ores carrying considerable quantities of iron and manganese oxides and very small quantities of gold and silver, and precious metal bearing ores carrying copper, lead, or zinc in quantities too low to classify them as copper, lead, zinc, or mixed ores. The distinction between gold and silver ores is not here made. The total number of silver mines and the total production of true silver ores are both very small. The copper ores include those containing 2.5 per cent or more of copper, or less than this percentage in the cases of the great disseminated copper deposits of the West and of the Lake Superior ores; in general, the lead ores are those containing 4.5 per cent or more of lead, and the zinc ores are those containing 25 per cent or more of zinc, both irrespective of their precious-metal content; but ores of lower grades in lead and especially in zinc are treated profitably in some places, and of course they are then classified as lead or zinc ores, as the case may be. The mixed ores are combinations of those enumerated.

*Ore produced and average extraction value of gold and silver per ton in 1916.*[a]

| State or Territory. | Dry or siliceous ores. | | Copper ores. | | Lead ores. | |
|---|---|---|---|---|---|---|
| | Quantity (short tons). | Average value. | Quantity (short tons). | Average value. | Quantity (short tons). | Average value. |
| Alabama and Georgia | 26,964 | $0.85 | 31,043 | | | |
| Alaska | 3,548,798 | 1.69 | 617,264 | $1.59 | | |
| Arizona | 336,304 | 6.46 | 16,491,971 | .35 | 73,747 | $6.43 |
| California | 2,192,078 | 5.47 | 933,722 | 2.38 | 32,763 | 7.62 |
| Colorado | 2,057,452 | 10.30 | 34,429 | 12.96 | 159,247 | 7.74 |
| Idaho | 71,683 | 8.38 | 113,050 | 1.93 | 1,373,579 | 3.96 |
| Maryland and Virginia [b] | 1 | 86.00 | 8,530 | .15 | | |
| Michigan [b] | | | 2,175,000 | .22 | | |
| Montana | 523,842 | 6.82 | 6,197,978 | 1.32 | 7,231 | 22.34 |
| Nevada | 1,688,661 | 9.27 | 4,146,956 | .34 | 37,513 | 9.48 |
| New Hampshire and Vermont | | | 4,679 | .35 | | |
| New Mexico | 264,358 | 7.82 | 3,452,910 | .11 | 14,925 | 3.78 |
| North Carolina | 3,753 | 4.90 | 165 | 2.14 | | |
| Oklahoma | 27 | 14.45 | | | | |
| Oregon | 123,613 | 8.56 | 35,409 | 3.23 | 49 | 69.20 |
| South Dakota | 1,870,721 | 4.06 | | | 62 | 13.35 |
| Tennessee | | | 482,495 | .14 | | |
| Texas | 50,361 | 8.18 | 2,081 | 8.34 | 147 | 5.96 |
| Utah | 89,363 | 10.61 | 12,676,152 | .32 | 665,217 | 9.07 |
| Washington | 70,476 | 9.35 | 68,230 | 1.83 | 9,099 | .58 |
| Wyoming | 2,813 | 6.85 | 6,063 | .75 | | |
| Total, 1916 | 12,921,268 | 5.73 | 47,478,127 | .51 | 2,373,579 | 5.95 |
| Percentage of tonnage | 19.46 | | 71.52 | | 3.58 | |
| Total, 1915 | 12,687,126 | 6.26 | 32,973,166 | .51 | 2,429,546 | 4.86 |
| Percentage of tonnage | 25.12 | | 65.28 | | 4.81 | |

| | Zinc ores. | | Copper-lead and copper-lead-zinc ores. | | Lead-zinc ores. | | Total. |
|---|---|---|---|---|---|---|---|
| | Quantity (short tons). | Average value. | Quantity (short tons). | Average value. | Quantity (short tons). | Average value. | |
| Alabama and Georgia | | | | | | | 58,007 |
| Alaska | | | | | | | 4,166,062 |
| Arizona | 52,652 | $2.66 | 23,180 | $3.55 | 55,956 | $2.61 | 17,033,810 |
| California | 29,079 | 1.38 | | | | | 3,187,642 |
| Colorado | 151,497 | .30 | 3,129 | 34.63 | 291,489 | 1.56 | 2,697,243 |
| Idaho | 23,158 | .52 | 22 | 15.82 | 1,136,553 | 2.16 | 2,718,045 |
| Maryland and Virginia [b] | (c) | | | | (c) | | 8,531 |
| Michigan [b] | | | | | | | 2,175,000 |
| Montana | 388,380 | 1.91 | 40,109 | 2.60 | 702,885 | 2.73 | 7,860,425 |
| Nevada | 31,886 | .44 | 2,846 | 11.96 | 33,303 | 3.77 | 5,941,165 |
| New Hampshire and Vermont | (d) | | | | 3,000 | .21 | 7,679 |
| New Mexico | 137,696 | .10 | 1,061 | 7.38 | (c) | | 3,870,960 |
| North Carolina | | | | | | | 3,918 |
| Oklahoma | | | | | | | 27 |
| Oregon | | | | | | | 159,071 |
| South Dakota | | | | | | | 1,870,783 |
| Tennessee [d] | | | | | | | 482,495 |
| Texas | 443 | | | | | | 53,032 |
| Utah | 18,400 | .10 | 9,645 | 10.82 | 461,866 | 2.44 | 13,920,643 |
| Washington | 154 | | | | 17,039 | | 164,998 |
| Wyoming | | | | | | | 8,876 |
| Total, 1916 | 833,345 | 1.21 | 79,992 | 5.54 | 2,702,091 | 2.31 | 66,388,402 |
| Percentage of tonnage | 1.25 | | 12 | | 4.07 | | |
| Total, 1915 | 512,634 | 1.32 | 10,951 | 15.55 | 1,900,029 | 2.06 | 50,513,452 |
| Percentage of tonnage | 1.01 | | .02 | | 3.76 | | |

[a] Illinois, Missouri, the Philippines, and Porto Rico not included; crude-ore tonnage containing precious metals not known.
[b] Includes only copper ore yielding precious metals.
[c] Included with zinc ores.
[d] Lead and zinc ores yielded no precious metals.

The total quantity of ore sold or treated and from which gold or silver was produced increased from 50,513,452 short tons in 1915 to 66,388,402 short tons in 1916, the largest quantity of such ores ever recorded. The total of such ores has increased more than 23,000,000 tons in two years. In 1916 the quantity of copper ores sold or treated increased more than 14,500,000 tons; dry or siliceous ores, more than 230,000 tons; zinc ores, 320,000 tons; copper-lead ores, 69,000 tons; and lead-zinc ores, 800,000 tons. Arizona, Utah, and Montana continued to lead in quantity of ore, owing to the largely increased output from copper mines, the ore from Arizona and Utah being mainly from low-grade disseminated ores and that from Montana mainly from the Butte vein deposits. Nevada ranked next in output of ore, mainly from Ely copper ores, but also from siliceous ores from Goldfield, Tonopah, and other districts. Alaska, New Mexico, California, Idaho, and Colorado come next, with an output mainly of dry or siliceous ores from many districts in Alaska, California, and Colorado, and of copper ores from the low-grade ore bodies in New Mexico.

The large production of lead and lead-zinc ores in Idaho ranked that State before South Dakota and California, which yielded ores that were mainly all dry or siliceous in character.

The average gold and silver extraction values were high for the siliceous ores of Colorado, New Mexico, Nevada, Montana, Oregon, Utah, Idaho, and Washington, and low for the larger ore bodies of California, South Dakota, and Alaska. Some of the States produced comparatively small quantities of copper ore carrying high extraction values in gold and silver, but the copper ores of the important copper-producing States showed low extraction values. The average recovery in gold and silver from the copper ores of Arizona was $0.35 a ton, that of Tennessee $0.14 a ton, that of Montana $1.32 a ton, that of Nevada $0.34, that of New Mexico $0.11, that of Utah $0.32, and that of Michigan $0.22. The lead ores of Utah showed an average recovery in gold and silver of $9.07 a ton, and the lead ores of Idaho only $3.98 a ton. Idaho produced the largest quantity of gold and silver bearing lead ores, and also lead-zinc ores. Utah yielded the next largest quantity of these classes of ore, but the gold and silver content of such ore was less than that of Montana ores of similar character. About 19.5 per cent of the output of ore considered as producing gold and silver was dry or siliceous ore, against 25 per cent in 1915; 71.5 per cent was copper ore, against 65 per cent in 1915; 3.58 per cent was lead ore; 4.07 per cent was lead-zinc ore; 1.25 per cent was zinc ore, and 0.12 per cent was copper-lead ore. The average precious-metal extraction value per ton of siliceous ores of the United States decreased from $6.26 to $5.73, that of zinc ores from $1.32 to $1.21, and that of copper-lead ores from $15.55 to $5.54. The average gold and silver value of copper ores per ton was 51 cents in each year, and that of lead-zinc ores increased from $2.06 to $2.31.

### DISTRIBUTION OF MINE PRODUCTION OF GOLD IN 1916, BY SOURCES.

As shown by the following table, the great bulk of the domestic output of gold is obtained from dry or siliceous ore—normally gold quartz and gold-silver quartzose ores—and from placers, more than

88 per cent of the total production of gold coming from these sources alone. The total contribution of gold derived from the great copper, lead, and zinc mines of the country is therefore relatively small, notwithstanding their recent enormous development and production of ore.

It is interesting to note, however, that the placer mines and dry or siliceous ores yielded 2 per cent less of the total gold than they did in 1915 and 4 per cent less than in 1914 and that the output of gold from placer mines, which had advanced from nearly 24 per cent of the total gold in 1910 to more than 25 per cent in 1914 and had declined to less than 23 per cent in 1915, increased to 25 per cent in 1916. This increase in percentage was due, however, not so much to increased output from placers as to smaller production from deep mines. The contribution of gold from dry or siliceous ores, which had gradually declined from about 69 per cent in 1910 to about 66 per cent in 1914 and had increased to nearly 68 per cent in 1915, decreased more than 4 per cent in 1916. The yield of gold from copper ores increased from 6 per cent in 1914 to 7 per cent in 1915 and to 9 per cent in 1916.

*Mine production of gold in 1916, in fine ounces.*[a]

| State or Territory. | Placers. | Dry or siliceous ores. | Copper ores. | Lead ores. | Zinc ores. | Copper-lead and copper-lead-zinc ores. | Lead-zinc ores. | Total. |
|---|---|---|---|---|---|---|---|---|
| Alabama | 37.59 | 380.85 | | | | | | 418.44 |
| Alaska | 538,897.50 | 286,028.60 | 9,141.76 | | | | | 834,067.86 |
| Arizona | 690.84 | 73,414.67 | 105,467.71 | 5,793.20 | 3,836.77 | 1,564.78 | 2,033.44 | 192,801.41 |
| California | 414,847.40 | 574,515.59 | 44,644.11 | 1,717.51 | 19.98 | | | 1,035,744.59 |
| Colorado | 34,487.70 | 847,876.76 | 15,220.87 | 22,687.40 | 330.62 | 1,724.04 | 4,238.70 | 926,566.09 |
| Georgia | 368.91 | 721.41 | | | | | | 1,090.32 |
| Idaho | 21,724.87 | 25,496.72 | 3,619.47 | 2,572.87 | 4.01 | 5.66 | 553.70 | 53,977.30 |
| Montana | 34,982.82 | 135,427.26 | 38,235.21 | 2,066.39 | 3,812.29 | 681.60 | 4,924.58 | 220,130.15 |
| Nevada | 17,139.89 | 351,420.33 | 50,880.78 | 3,046.56 | | 29.60 | 387.05 | 428,904.21 |
| New Mexico | 537.74 | 54,360.53 | 11,336.28 | 319.29 | 298.63 | 25.00 | | 66,877.47 |
| North Carolina | 381.83 | 878.54 | 8.85 | | | | | 1,269.22 |
| Oregon | 42,208.01 | 47,415.10 | 2,234.82 | 159.98 | | | | 92,017.91 |
| South Carolina | 15.48 | | | | | | | 15.48 |
| South Dakota | 102.12 | 360,798.54 | | 7.99 | | | | 360,908.65 |
| Tennessee | | 277.63 | | | | | | 277.63 |
| Texas | | | 6.01 | 14.02 | | | | 20.03 |
| Utah | 60.47 | 9,122.41 | 113,396.52 | 33,535.63 | | 421.68 | 16,401.35 | 172,938.06 |
| Virginia | | 4.11 | 38.70 | | | | | 42.81 |
| Washington | 400.40 | 26,979.03 | 563.76 | .87 | | | | 27,944.06 |
| Wyoming | 16.88 | 923.55 | 54.45 | | | | | 994.88 |
| Total, 1916 | 1,106,900.45 | 2,796,041.63 | 400,849.30 | 71,921.71 | 8,302.30 | 4,452.36 | 28,538.82 | 4,417,006.57 |
| Value | $22,881,663 | $57,799,310 | $8,286,290 | $1,486,754 | $171,624 | $92,039 | $589,950 | $91,307,630 |
| Percentage of total | 25.06 | 63.30 | 9.07 | 1.63 | .19 | .10 | .65 | |
| Total, 1915 | 1,077,432.25 | 3,212,297.79 | 343,225.93 | 84,448.66 | 4,974.50 | 2,496.30 | 29,599.24 | 4,754,474.67 |
| Value | $22,272,501 | $66,404,089 | $7,095,110 | $1,745,709 | $102,832 | $51,603 | $611,870 | $98,283,714 |
| Percentage of total | 22.66 | 67.57 | 7.22 | 1.78 | 0.10 | 0.05 | 0.62 | |

[a] Philippines and Porto Rico not included.

## PLACERS.

### GENERAL.

The total value of the production of gold from placers was $22,881,663 in 1916, against $22,272,501 in 1915. The placer production increased in Alaska, Oregon, and Colorado in 1916, but decreased in Nevada, California, Idaho, and Montana.

The placer production is derived chiefly from dredging, from drift mining (which is of decreasing importance in Alaska in frozen ground at no great depth, but of continued importance in California in ancient buried river channels, often at considerable depth), and from hydraulic and sluicing placers. In California, especially, hydraulic mining was of much importance in the past and had become a special branch of the industry in itself, but restrictive laws relative to the débris and to disturbance of navigable streams have in recent years greatly confined mining activity of this kind. Finally, there is a small annual output of gold from dry placers in the Southwest and also a production of gold and platinum from ocean-beach mining in California and Oregon.

Some interesting notes on beach mining in California and Oregon and on dry placers in California, by Charles G. Yale, and on dry placers in Arizona, Nevada, and New Mexico, by V. C. Heikes, were published in the Survey report on gold and silver for 1912, copies of which can still be had on application to the Director, United States Geological Survey, Washington, D. C.

### DREDGING.

The production of gold by dredging in the United States and Alaska from the commercial beginning of the industry in 1896 to the record output of 1916, inclusive, has amounted in value according to best available data to $120,103,117, of which $86,880,458 came from California, $15,109,894 from Alaska, $8,099,733 from Montana, $4,103,649 from Colorado, and $3,632,056 from Idaho. Oregon produced more gold from dredging in 1916 than Montana or Idaho and nearly as much as Colorado.

Brief details of dredging operations have been given in Mineral Resources in the mines reports on gold, silver, copper, lead, and zinc of the Western States and also in earlier reports of the Director of the Mint. A brief history of gold dredging in the United States was given in the gold and silver (general) report for the year 1914, and the gold production obtained by dredging in the United States and Alaska from 1896 to the end of 1914, and the number of dredges operated was given by States for each year. Further information is to be found in reports of geological surveys or mining officials of different States. A comprehensive and very useful report is contained in Bulletin 57 of the California State Mining Bureau, "Gold dredging in California," by W. B. Winston and Charles Janin. Another valuable treatise is "Dredging for gold in California," by D'Arcy Weatherbe, published by the Mining and Scientific Press; and a recent valuable contribution is that on "The history and development of gold dredging in Montana," by Hennen Jennings, with a chapter on placer mining methods and costs, by Charles Janin, published as Bulletin 121 of the Bureau of Mines.

The gold recovered in the United States and Alaska by 113 gold dredges in 1916 was $12,786,614, against $12,483,125 by 114 dredges in 1915. Of the production in 1916 California yielded $7,769,227 from 60 dredges, Alaska $2,679,000 from 34 dredges, Montana $642,572 from 5 dredges, Colorado $695,265 from 6 dredges, and Idaho $327,696 from 4 dredges. Two dredges operating in Baker County and one in Josephine County, Oreg., produced $670,415.

*Gold produced in the United States by dredges, 1896–1916.*

| Year. | Dredges. | California. | Alaska. | All other States.a | Total. |
|---|---|---|---|---|---|
| 1896 | 2 | $2,000 | ..... | $42,000 | $44,000 |
| 1897 | 6 | 5,000 | ..... | 113,556 | 118,556 |
| 1898 | 8 | 18,887 | ..... | 168,813 | 187,700 |
| 1899 | 18 | 206,302 | ..... | 227,876 | 434,178 |
| 1900 | 27 | 200,929 | ..... | 319,108 | 520,037 |
| 1901 | 34 | 471,762 | ..... | 268,251 | 740,013 |
| 1902 | 48 | 867,665 | ..... | 501,857 | 1,369,522 |
| 1903 | 45 | 1,475,749 | $20,000 | 420,315 | 1,916,064 |
| 1904 | 61 | 2,187,038 | 25,000 | 511,679 | 2,723,717 |
| 1905 | 68 | 3,276,141 | 40,000 | 371,235 | 3,687,376 |
| 1906 | 76 | 5,098,359 | 120,000 | 503,035 | 5,721,394 |
| 1907 | 79 | 5,065,437 | 250,000 | 340,265 | 5,655,702 |
| 1908 | 88 | 6,536,189 | 170,901 | 646,481 | 7,353,571 |
| 1909 | 96 | 7,382,950 | 424,993 | 975,656 | 8,783,599 |
| 1910 | 115 | 7,550,254 | 800,000 | 942,786 | 9,293,040 |
| 1911 | 119 | 7,666,461 | 1,500,000 | 1,159,908 | 10,326,369 |
| 1912 | 124 | 7,429,955 | 2,200,000 | 1,588,956 | 11,218,911 |
| 1913 | 116 | 8,090,294 | 2,200,000 | 1,936,642 | 12,226,936 |
| 1914 | 120 | 7,783,394 | 2,350,000 | 2,379,389 | 12,512,783 |
| 1915 | 114 | 7,796,465 | 2,330,000 | 2,356,660 | 12,483,125 |
| 1916 | 113 | 7,769,227 | 2,679,000 | 2,338,487 | 12,786,614 |
| Total | | 86,880,458 | 15,109,894 | 18,112,965 | 120,103,117 |

a Other States that have produced gold by dredges are Colorado, which yielded, 1901–1916, $4,103,649; Idaho, 1897–1916, $3,632,056; Montana, 1896–1916, $8,099,733; and Oregon, New Mexico, Nevada, South Dakota, Wyoming, Alabama, Georgia, and North Carolina, a combined yield, 1902–1916, of $2,187,327.

## DRY AND SILICEOUS ORES.

In 1916 dry and siliceous ores, including true gold, gold-silver, and silver ores, and precious metal ores not classed primarily as copper, lead, zinc, or mixed ores, produced $57,799,310 in gold, against $66,404,089 in 1915. The largest producers from this class of ore are in order of rank: Colorado, California, South Dakota, Nevada, and Alaska.

The siliceous ores are in part free-milling (amalgamating), as in Alaska, California, and Oregon; in part both amalgamating and concentrating, as in many States; in smaller part simply concentrating ores, as in parts of Colorado and Arizona; in increasing part all-sliming and cyaniding ores; and finally in some part smelting ores. Tailings both from old dumps and from present millings are largely reworked by concentration and subsequent cyanidation.

The loss in tailings from gold mills is being constantly cut down, and the most serious loss remains in tailings from concentrating plants. The chlorination process is of decreasing relative importance, having been used in only a few plants in California and Colorado in 1916. Smelting is mainly of concentrates and of siliceous and pyritic ores, which are also valuable as fluxes. Exact figures of relative output by methods will appear in detail by States in another table.

## COPPER ORES.

The production of gold as a by-product of the smelting of copper ores sold or treated in 1916 was $8,286,290, against $7,095,110 in 1915, an increase from 7.22 per cent of the total gold yield in 1915 to 9.07 per cent in 1916. The largest production was in Utah, followed by Arizona, Nevada, California, and Montana, in the order given.

## LEAD ORES.

The production of gold from refining lead bullion from lead ores sold or treated in 1916, chiefly from Utah and Colorado, was $1,486,754 against $1,745,709 in 1915, or 1.63 per cent of the total domestic output of gold in 1916.

## LEAD-ZINC, ZINC, AND OTHER ORES.

The production of gold from lead-zinc ores was $589,950 in 1916, against $611,870 in 1915; from zinc ores $171,624 in 1916, against $102,832 in 1915; and from copper-lead and copper-lead-zinc ores $92,039 in 1916, against $51,603 in 1915.

## DISTRIBUTION OF MINE PRODUCTION OF SILVER IN 1916, BY SOURCES.

The mine production of silver from the three most important sources of silver—dry or siliceous ores, copper ores, and lead ores—was 87 per cent of the total output in 1916. The output from dry and siliceous ores decreased 4.35 per cent in 1916, following a decrease of 4.5 per cent in 1915; that from lead ores decreased 3 per cent; that from lead-zinc ores increased about 2 per cent; and that from copper ores increased more than 5 per cent. The combined output from placers, zinc ores, copper-lead, and copper-lead-zinc ores was a little more than 2.4 per cent of the total production of silver.

*Mine production of silver in 1916, in fine ounces.* [a]

| State or Territory. | Placers. | Dry or siliceous ores. | Copper ores. | Lead ores. | Zinc ores. | Copper-lead and copper-lead-zinc ores. | Lead-zinc ores. | Total. |
|---|---|---|---|---|---|---|---|---|
| Alabama | 23 | 30 | | | | | | 53 |
| Alaska | 62,000 | 110,050 | 1,207,121 | | | | | 1,379,171 |
| Arizona | 171 | 997,372 | 5,347,393 | 539,108 | 92,264 | 75,984 | 159,247 | 7,212,039 |
| California | 29,611 | 179,199 | 1,969,783 | 326,468 | 60,293 | | | 2,564,354 |
| Colorado | 9,189 | 5,562,217 | 190,824 | 1,159,615 | 58,722 | 110,531 | 556,446 | 7,656,544 |
| Georgia | 35 | 39 | | | | | | 74 |
| Idaho | 4,712 | 112,519 | 218,598 | 8,227,936 | 18,228 | 351 | 3,718,529 | 12,300,873 |
| Illinois [b] | | | | 5,684 | | | | 5,684 |
| Maryland and Virginia | | 2 | 1,356 | | | | | 1,358 |
| Michigan | | | 716,640 | | | | | 716,640 |
| Missouri | | | | 129,450 | | | | 129,450 |
| Montana | 5,342 | 1,175,791 | 11,226,084 | 180,601 | 1,008,141 | 139,047 | 2,759,410 | 16,494,366 |
| Nevada | 5,744 | 12,751,911 | 384,393 | 444,585 | 21,613 | 50,808 | 178,476 | 13,837,525 |
| New Mexico | 72 | 1,436,172 | 231,091 | 75,704 | 12,117 | 11,118 | | 1,766,274 |
| North Carolina | 62 | 341 | 260 | | | | | 663 |
| Oklahoma | | 606 | | | | | | 606 |
| Oregon | 9,249 | 118,143 | 103,822 | 128 | | | | 231,342 |
| South Carolina | 28 | | | | | | | 28 |
| South Dakota | 6 | 214,190 | | 1,009 | | | | 215,205 |
| Tennessee | | | 94,701 | | | | | 94,701 |
| Texas | | 626,246 | 26,177 | 1,032 | | | | 653,455 |
| Utah | 2 | 1,153,993 | 2,633,402 | 8,118,264 | 2,914 | 145,439 | 1,199,023 | 13,253,087 |
| Vermont and New Hampshire | | | 2,501 | | | | 945 | 3,446 |
| Washington | 104 | 154,546 | 172,404 | 8,002 | | | 65 | 335,121 |
| Wyoming | 1 | 289 | 5,234 | | | | | 5,524 |
| Total, 1916 | 126,351 | 24,593,656 | 24,541,234 | 19,216,586 | 1,274,292 | 533,273 | 8,572,141 | 78,857,533 |
| Value | $83,139 | $16,182,625 | $16,148,132 | $12,644,514 | $838,484 | $350,804 | $5,640,469 | $51,899,866 |
| Percentage of total | 0.16 | 31.18 | 31.12 | 24.37 | 1.61 | 0.68 | 10.88 | 100 |
| Total, 1915 | 154,968 | 25,709,505 | 18,781,365 | 19,828,533 | 1,136,220 | 284,047 | 6,509,092 | 72,353,730 |
| Value | $78,569 | $13,034,719 | $9,522,152 | $10,053,066 | $576,063 | $118,662 | $3,300,109 | $36,683,340 |
| Percentage of total | 0.21 | 35.53 | 25.96 | 27.40 | 1.57 | 0.33 | 9.00 | 100 |

[a] Philippines and Porto Rico not included in table. [b] Fluorspar-lead ore.

### PLACERS.

The output of silver from the refining of placer gold was 126,351 fine ounces in 1916, against 154,968 ounces in 1914. Seventy-three per cent of the production was from Alaska and California.

### DRY AND SILICEOUS ORES.

The mine production of silver from dry and siliceous ores in 1916 was 24,593,656 fine ounces, against 25,709,505 ounces in 1915. About 52 per cent of this was from Nevada (chiefly from the Tonopah district) and 22 per cent was from Colorado (mainly from the Leadville, Upper San Miguel, and Sneffels districts). New Mexico, Montana, and Utah also each produced more than 1,000,000 ounces of silver from this source, and Arizona nearly 1,000,000 ounces. Ninety-six per cent of the silver produced in Texas was from siliceous silver ores.

A large part of the silver from gold-silver siliceous ores is obtained with the gold by amalgamation and cyanidation in the mills, and the silver is recovered by refining the mill bullion. The remainder is produced by smelting the richer ores and refining the copper or lead bullion produced.

### COPPER ORES.

The mine production of silver from domestic copper ores in 1916 was 24,541,234 fine ounces, against 18,781,365 ounces in 1915, an increase of about 31 per cent. The increase in production of silver from copper ores mined in Alaska was 410,000 ounces; Arizona, 1,552,000 ounces; Utah, 568,000 ounces; Montana, 2,406,000 ounces; and California, 913,000 ounces.

The production of silver from copper ores is from the electrolytic refining of Lake and blister copper produced by smelting. The copper ores are mainly sulphides (except the Lake ores of Michigan, which are native metal in amygdaloid and conglomerate matrix), and a greater tonnage contains chalcocite than chalcopyrite or cupriferous pyrite. The great disseminated copper deposits of Utah, Arizona, Nevada, and New Mexico are of increasing importance, and the lode deposits of Butte, Mont., have long been famous. The silver tenor of the extensive Chino disseminated deposits of the Santa Rita district, New Mex., is notably low, but similar deposits elsewhere add large quantities of silver.

The copper ore from Michigan and the silver recovered in refining the metal derived therefrom, being deducted, it appears that 47,303,127 tons of copper ore yielded 23,824,594 ounces of silver, or slightly more than 0.5 ounce per ton.

In output of silver from copper ores Montana continued to lead with 11,226,034 ounces in 1916 against 8,819,772 ounces in 1915; Arizona followed with 5,347,893 ounces in 1916 against 4,010,510 ounces in 1915; Utah ranked third with 2,633,402 ounces in 1916 against 2,065,661 ounces in 1915; and California produced 1,969,783 ounces in 1916 against 1,056,895 ounces in 1914. The production of Montana is mainly from Butte, that of Arizona has been chiefly from Bisbee and Jerome, that of Utah from Tintic and Bingham, and that of California from Shasta County. Of these districts Bisbee well

represents the disseminated type; Bingham produces from both lode and disseminated deposits; and the remainder produce silver chiefly from copper ore mined from deep lodes.

## LEAD ORES.

The mine production of silver from argentiferous lead ores in 1916 was 19,216,586 fine ounces, against 19,828,533 ounces in 1915. The apparent decrease was caused by classifying as lead-zinc ores some ores that formerly were classified as lead ores. The output from Idaho decreased from 9,791,944 ounces in 1915 to 8,227,936 ounces in 1916, that of Utah increased from 7,759,842 ounces to 8,118,264 ounces, and that of Colorado from 964,224 ounces to 1,159,615 ounces. The yield in Idaho is mainly from the silver-lead ores of the Cœur d'Alene, that in Utah is chiefly from the Park City and Tintic districts, and that in Colorado from Aspen and Leadville. Most of the output is from the desilverization of lead bullion from smelting of western ores and concentrates.

## ZINC, LEAD-ZINC, AND MIXED ORES.

Argentiferous zinc ores produced 1,274,292 ounces of silver in 1916, against 1,136,220 ounces in 1915, mainly as refinery by-products from the smelting of zinc concentrates from Montana, Idaho, California, and Arizona. The production from Montana zinc ores increased from 734,798 ounces in 1915 to 1,008,141 ounces in 1916.

Lead-zinc ores produced 8,572,141 fine ounces of silver in 1916, against 6,509,092 ounces in 1915, chiefly from concentrates from the Cœur d'Alene in Idaho, the Butte district in Montana, and the Park City region in Utah. The output from Idaho increased from 1,586,347 ounces in 1915 to 3,718,529 ounces in 1916.

Copper-lead and copper-lead-zinc ores produced 533,273 ounces of silver in 1916 against 234,047 ounces in 1915. The output was mainly from Utah, Montana, Colorado, and Arizona.

*Production of silver in the United States, by sources, as reported by mines, 1905–1916, in fine ounces.*[a]

| Year. | Placers. | Dry or siliceous ores. | Copper ores. | Lead ores. | Zinc ores. | Copper-lead and copper-lead-zinc ores. | Lead-zinc ores. | Total. |
|---|---|---|---|---|---|---|---|---|
| 1905 | 112,826 | 17,187,889 | 15,762,947 | 16,070,203 | 939,252 | 5,416,723 | 782,656 | 56,272,496 |
| 1906 | 171,058 | 16,792,799 | 15,880,870 | 15,328,653 | 98,423 | 6,815,678 | 2,274,972 | 57,362,453 |
| 1907 | 126,808 | 19,038,042 | 13,955,436 | 17,318,811 | 93,419 | 489,825 | 1,474,725 | 52,497,066 |
| 1908 | 159,285 | 19,862,038 | 14,945,189 | 14,049,481 | 37,605 | 1,099,283 | 722,906 | 50,875,787 |
| 1909 | 152,040 | 19,826,890 | 18,300,705 | 17,027,737 | 313,948 | 549,923 | 1,141,434 | 57,312,677 |
| 1910 | 159,381 | 23,125,042 | 16,024,543 | 15,028,076 | 755,369 | 535,987 | 1,968,311 | 57,596,709 |
| 1911 | 170,084 | 25,205,749 | 16,759,638 | 15,596,638 | 630,573 | 285,006 | 2,460,152 | 61,107,840 |
| 1912 | 163,955 | 26,363,436 | 18,744,661 | 16,632,377 | 664,421 | 654,596 | 2,810,939 | 66,034,385 |
| 1913 | 123,739 | 28,010,875 | 18,250,253 | 18,629,246 | 86,432 | 752,563 | 5,334,120 | 71,187,228 |
| 1914 | 152,128 | 27,812,335 | 14,829,828 | 19,302,081 | 145,264 | 248,866 | 7,132,747 | 69,623,249 |
| 1915 | 154,968 | 25,709,505 | 18,781,365 | 19,828,533 | 1,136,220 | 234,047 | 6,509,092 | 72,353,730 |
| 1916 | 126,351 | 24,593,656 | 24,541,234 | 19,216,586 | 1,274,292 | 533,273 | 8,572,141 | 78,857,533 |
| | 1,772,623 | 273,528,256 | 206,776,669 | 204,028,422 | 6,175,218 | 17,615,770 | 41,184,195 | 751,081,153 |

[a] Philippine Islands excluded.

This table shows that the production of silver as reported by the mines has increased from 50,875,787 fine ounces in 1908 to 78,857,533 ounces in 1916. The production from siliceous, copper, lead, zinc, and lead-zinc ores all show an increase. The recoveries from dry or siliceous ores reached its apex in 1913 when the yield from Tonopah mines was at its zenith, and the production in 1916 was about 3,400,000 ounces less than it was in 1913. The yield of silver from copper ores has increased from 13,955,436 ounces in 1907 to 24,541,234 ounces in 1916, or about 76 per cent. The total yield of silver from zinc ores has been comparatively small, though the output from that kind of ore increased from 37,605 ounces in 1908 to nearly 1,300,000 ounces in 1916. The combined production of silver from lead and lead-zinc ore increased from 14,772,389 ounces in 1908 to 27,788,727, or nearly 90 per cent.

## DISTRIBUTION OF PRODUCTION OF GOLD AND SILVER BY METHODS OF TREATMENT.

In the following table is given a summary of the distribution of the production of gold and silver in the United States in 1916, showing (1) total crude ore, tailings, and slags sold or treated; (2) crude ore treated in gold and silver mills; (3) crude ore concentrated and resulting concentrates; (4) crude ore shipped to smelters; (5) old tailings and slags treated. The last four items include recoverable gold and silver content in fine ounces.

*Distribution of gold and silver produced in 1916, by States.*[a]

| State or Territory. | Total quantity of ore, tailings, and slag treated or sold in 1916. | Ore to gold and silver mills. | | | Crude ore— | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | To concentrating mills. | Concentrates produced from all sources. | | |
| | | Quantity. | Gold in bullion. | Silver in bullion. | Quantity. | Quantity. | Gold. | Silver. |
| | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Short tons.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* |
| Alaska | 4,166,062 | 3,368,685 | 166,511 | 32,309 | 587,633 | 34,293 | 119,518 | 412,143 |
| Arizona | 17,033,810 | 275,839 | 68,957 | 658,830 | 12,851,367 | 853,576 | 19,616 | 1,179,552 |
| California | 3,187,642 | 2,092,137 | 438,261 | 117,214 | 214,793 | 56,448 | 117,966 | 74,298 |
| Colorado | 2,697,243 | 1,442,139 | 581,178 | 536,763 | 702,200 | 288,211 | 106,596 | 2,409,006 |
| Idaho | 2,718,045 | 69,773 | 22,480 | 20,420 | 2,387,881 | 386,359 | 4,609 | 8,316,476 |
| Montana | 7,860,425 | 351,014 | 60,328 | 243,164 | 6,629,675 | 2,238,167 | 46,001 | 13,142,845 |
| Nevada | 5,941,165 | 1,424,135 | 331,001 | 11,326,955 | 4,066,727 | 561,950 | 48,459 | 1,107,119 |
| New Mexico | 3,870,950 | 135,267 | 34,332 | 841,865 | 3,442,681 | 311,726 | 13,125 | 336,472 |
| Oregon | 159,071 | 123,232 | 45,344 | 105,921 | ..... | 2,521 | 1,755 | 19,902 |
| South Dakota | 1,870,783 | 1,870,249 | 359,781 | 212,779 | ..... | 22 | 114 | 38 |
| Texas | 53,032 | 50,361 | ..... | 626,346 | ..... | ..... | ..... | ..... |
| Utah | 13,920,643 | 1,423 | 309 | 340 | 12,228,926 | 748,903 | 69,369 | 2,473,132 |
| Washington | 164,998 | 11,702 | 7,133 | 1,015 | 53,635 | 4,130 | 44 | 92,543 |
| Wyoming | 8,876 | 2,764 | 786 | 283 | ..... | ..... | ..... | ..... |
| Eastern or Appalachian States | 756,632 | 30,716 | 1,851 | 332 | 205,811 | 9,910 | ..... | 2,624 |
| Total | 64,409,377 | 11,249,436 | 2,118,252 | 14,724,426 | 43,371,329 | 5,496,226 | 547,172 | 29,566,150 |
| Total 1915 | 48,514,980 | 11,508,953 | 2,416,590 | 16,503,801 | 29,602,270 | 4,127,411 | 528,507 | 25,778,129 |

[a] Exclusive of small quantity of silver from copper ores in Michigan and Missouri, and from lead ores in Illinois and Missouri, and of gold and silver from the Philippine Islands and Porto Rico.

*Distribution of gold and silver produced in 1916, by States.*—Continued.

| State or Territory. | Crude ore to smelters. | | | Old tailings and slag treated. | | |
|---|---|---|---|---|---|---|
| | Quantity. | Gold. | Silver. | Quantity. | Gold. | Silver. |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Short tons.* | *Fine ounces.* | *Fine ounces.* |
| Alaska | 209,744 | 9,141 | 872,719 | | | |
| Arizona | 3,773,733 | 103,015 | 5,305,608 | 132,871 | [a] 523 | [a] 67,878 |
| California | 789,961 | 56,877 | 2,303,655 | 90,751 | 7,793 | 39,576 |
| Colorado | 552,904 | 204,304 | 4,701,596 | | [b] | [b] |
| Idaho | 249,964 | 5,133 | 3,944,355 | 10,427 | 30 | 14,910 |
| Montana | 710,224 | 78,629 | 3,059,096 | 169,512 | [c] 189 | [c] 43,919 |
| Nevada | 371,058 | 31,713 | 1,380,392 | 79,260 | [d] 591 | [d] 17,415 |
| New Mexico | 293,002 | 18,882 | 587,865 | | | |
| Oklahoma | 27 | | 606 | | | |
| Oregon | 35,839 | 2,701 | 96,270 | | | |
| South Dakota | 534 | 912 | 2,382 | | | |
| Texas | 2,671 | 20 | 27,209 | | | |
| Utah | 1,281,576 | 102,151 | 10,536,058 | 408,718 | 1,049 | 243,505 |
| Washington | 98,661 | 20,367 | 241,459 | 1,000 | [e] | [e] |
| Wyoming | 6,112 | 192 | 5,240 | | | |
| Eastern or Appalachian States | 518,604 | 329 | 97,141 | 1,501 | [f] 130 | [f] 78 |
| Total | 8,894,609 | 634,366 | 33,161,551 | 894,060 | 10,305 | 427,281 |
| Total 1915 | 7,018,379 | 728,132 | 29,074,428 | 385,378 | 3,814 | 194,901 |

[a] Gold and silver from 18,352 tons of old tailings included under recoveries from gold and silver mills.
[b] Included under recoveries from gold and silver mills.
[c] Gold and silver from 49,505 tons of old tailings included under recoveries from gold and silver mills.
[d] Gold and silver from 75,005 tons of old tailings included under recoveries from gold and silver mills.
[e] Gold and silver from 1,000 tons of old tailings included under recoveries from gold and silver mills.
[f] Gold and silver from 540 tons of old tailings included under recoveries from gold and silver mills.

The first item consists of all classes of ores, tailings, and slags from which gold and silver was produced in 1916. The grand total is 64,409,377 short tons in 1916, against 48,514,980 tons in 1915. This takes no account of placer gravel but represents output of mines producing ore only. The greatest output was from Arizona, Utah, Montana, Nevada, and Alaska, all notable for large yield of copper ores.

In reference to the second item many gold and silver mills employ concentrating apparatus, and the concentrates obtained are combined in the table with those from straight concentrating mills under the heading "Concentrates produced." The gold and silver recovery under this item is mainly by amalgamation and cyanidation, as is shown in detail in the last table of this report. The total quantity of crude ore treated in gold and silver mills in 1916 was 11,249,436 short tons, against 11,508,953 tons in 1915. The greatest quantities milled were in Alaska, California, South Dakota, Colorado, and Nevada. The total recovery of gold from the mills was 2,118,252 fine ounces in 1916, against 2,416,590 ounces in 1915, and the production was, as usual, chiefly from Colorado, California, South Dakota, and Nevada, in the order named. The total silver recovery in mills was 14,724,426 fine ounces, against 16,503,801 ounces in 1915, and came very largely from Nevada (from Tonopah and Goldfield chiefly), but also in considerable part from New Mexico, Arizona, Texas, and Colorado.

Under the third item is given the quantity of ore treated by concentration only, including the large quantities of copper, lead, zinc, and mixed ores, whose concentrates are smelted primarily for these metals, the gold and silver being recovered in refining the copper and lead bullion and smelting the zinc residues. Examples are the copper ores of the disseminated deposits of Bingham, Utah, and of New Mexico and Nevada; the copper ores of Butte, Mont., the lead

and lead-zinc ores of Coeur d'Alene, Idaho, Butte, Mont., and Leadville, Colo. The quantity of concentrates produced and the recoverable gold and silver content, however, as already stated, represent not only the concentrates from these straight concentrating mills but also those from gold and silver mills. These concentrates are mainly smelted but are also treated in gold and silver mills by the processes named. The ore treated in straight concentration mills increased from 29,602,270 short tons in 1915 to 43,371,329 tons in 1916, mainly because of the much greater activity at copper mines. Arizona ranked first in quantity of ore concentrated, followed by Utah, Montana, Nevada, New Mexico, and Idaho. These quantities, with the exception of those of Montana and Idaho, represent largely low-grade disseminated copper ores milled. The total quantity of gold and silver bearing concentrates from all classes of milling ore increased from 4,127,411 short tons in 1915 to 5,496,226 tons in 1916. Montana mills produced the largest quantity of concentrates, or 40 per cent, followed by those of Arizona, Utah, Nevada, and Idaho. The total recoverable gold content of all concentrates was 547,172 ounces in 1916, against 528,507 ounces in 1915, and came mainly from Alaska, California, Colorado, Utah, and Nevada, in the order named. The total recoverable silver from concentrates produced was 29,566,150 fine ounces in 1916, against 25,778,129 ounces in 1915, and came chiefly from Montana, Idaho, Utah, Colorado, and Arizona.

The fourth item covers the quantity and the recoverable precious-metal content of crude ores shipped from the mines direct to the smelters, and in general includes the richer gold, silver, copper, lead, and mixed ores from which the gold and silver is eventually recovered by refining the copper or lead bullion that collects the precious metals in the smelting. The total quantity shipped of this class of ore increased from 7,018,379 short tons in 1915 to 8,894,609 tons in 1916. The output was notably from Arizona, followed by Utah, California, Montana, Eastern or Appalachian States, and Colorado, in the order named. The total yield of gold from crude ores smelted decreased from 728,132 fine ounces in 1915 to 634,366 ounces in 1916, and came chiefly from Colorado, Arizona, Utah, Montana, California, and Nevada, in the order given. The total recoverable silver output increased from 29,074,428 fine ounces in 1915 to 33,161,551 ounces in 1916, and was notably from Utah, Arizona, Colorado, Idaho, and Montana.

Under the fifth item is given the quantity of old materials, principally tailings and slags, re-treated, and their recoverable contents. These are partly smelted, often for their fluxing as well as their metal value; but considerable quantities of old tailings are now concentrated and cyanided, and impounding of mill tailings for future treatment as well as because of legal requirements has now become a general practice. The total quantity of all old material treated as shown in the table increased from 385,378 short tons in 1915 to 894,030 tons in 1916. Most of the gold and silver derived from old tailings is included under recoveries by amalgamation and cyanidation at gold and silver mills.

From this table the output of ore from the Central States, producing small quantities of silver and no gold, has been omitted. The output of zinc ore from the Eastern States is also omitted, as this zinc ore is reported to produce neither silver nor gold.

*Percentage of output of gold and silver produced by different processes, 1912–1916.*

| Process. | Percentage of total output. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gold. | | | | | Silver. | | | | |
| | 1912 | 1913 | 1914 | 1915 | 1916 | 1912 | 1913 | 1914 | 1915 | 1916 |
| Placers | 24.8 | 24.9 | 25.2 | 22.7 | 25.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Gold and silver mills: | | | | | | | | | | |
| By amalgamation | 22.3 | 21.5 | 20.9 | 22.8 | 21.5 | 1.2 | .6 | .4 | .4 | .4 |
| By cyanidation | 30.9 | 31.2 | 31.4 | 30.4 | 28.1 | 17.8 | 19.7 | 22.1 | 22.1 | 18.3 |
| By chlorination | .4 | .3 | .4 | .5 | .5 | ..... | ..... | ..... | ..... | ..... |
| Total milling | 53.6 | 53.0 | 52.5 | 53.7 | 50.1 | 19.0 | 20.3 | 22.5 | 22.5 | 18.7 |
| Smelting [a] | 21.6 | 22.1 | 22.1 | 23.6 | 24.9 | 80.8 | 79.5 | 77.3 | 77.3 | 81.1 |
| Total [b] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

[a] Both crude ore and concentrates. [b] Philippine Islands and Porto Rico excluded.

The placers produced about 25 per cent of the total output of gold, an increase of 2 per cent. The dredges produced a little more gold in 1916 than in 1915, and the combined placer yield from hydraulic, drift, and other surface methods was greater. The increase from placers was largely due to a greater output from Alaska. The percentage of output of silver credited to the placers is insignificant.

In the mills the amalgamation process showed a loss of 1.3 per cent of the total gold recovery in 1916. This was due to the decreases in mining and milling in Colorado, California, and Nevada, which produce ores more amenable to treatment by amalgamation. The gold recovered by cyanidation showed a decrease of 2.3 per cent, which may have been partly due to the much increased cost of cyanide and of zinc dust and shavings, but was mainly due to the lower grade of siliceous ores mined in Nevada. The chlorination process was only used in a few mills in California and Colorado, and the output of gold was about $100,000 less in 1916 than in 1915.

Experiments continue to be made in the concentration of sulphide ores carrying gold and silver by the flotation process, and a much increased quantity of ore was treated in 1916. A large quantity of concentrates from these ores are now smelted and the successful application of the flotation process has resulted in decreased yield of gold and silver from cyanidation. It is probable, however, that this decrease may not continue at the same rate, for at least part of the flotation concentrates will be cyanided and not shipped to smelters. This method is said to have been adopted by the Goldfield Consolidated Mines Co., which has retained part of the cyanide plant for treatment of tailings and the flotation concentrates. The larger companies which will change the process of treating ores can reasonably be expected to cyanide the flotation concentrates.

The smelters, which had for three years been producing each year a slightly greater proportion of gold and a smaller proportion of silver, are to be credited in 1916 with about 24.9 per cent of the total output of gold and 81.1 per cent of the silver. The increase in 1916 was due to the very much larger quantity of copper and lead-zinc ores and concentrates smelted.

The bulk of the gold output remains mainly from the gold mills, but in decreasing proportion. In 1916 the output from cyanidation decreased, as did the recoveries by amalgamation and chlorination, and the increase in gold was entirely from the placers and from the smelting of crude ores and concentrates.

The following table shows in greater detail the ore treated and the output of gold and silver mills, by States, in 1916:

*Gold and silver produced at mills in 1916.*[a]

| State. | Ore and tailings treated. | Bullion recovered. | | | | Percentage of gold and silver from all sources. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Amalgamation. | | Cyanidation. | | Amalgamation. | | Cyanidation. | |
| | | Gold. | Silver. | Gold. | Silver. | Gold. | Silver. | Gold. | Silver. |
| | *Short tons.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | *Fine ounces.* | | | | |
| Alaska | 3,368,685 | 165,273 | 31,875 | 80,337 | 6,554 | 19.8 | 2.3 | 9.6 | 0.5 |
| Arizona | 294,191 | 5,513 | 10,448 | 63,444 | 648,382 | 3.8 | .1 | 32.9 | 9.0 |
| California[b] | 2,092,137 | 413,033 | 94,008 | 56,974 | 75,369 | 39.8 | 3.7 | 5.5 | 2.9 |
| Colorado[b] | c1,442,139 | 46,346 | 23,612 | 530,466 | 510,991 | 5.0 | .3 | 57.2 | 6.7 |
| Idaho | 69,773 | 18,084 | 12,529 | 4,396 | 7,891 | 33.5 | .1 | 8.1 | .06 |
| Montana | 400,519 | 4,983 | 2,690 | 55,345 | 240,474 | 2.3 | ..... | 25.1 | 1.5 |
| Nevada | 1,499,140 | 37,376 | 25,094 | 293,625 | 11,301,861 | 8.7 | .2 | 68.4 | 81.7 |
| New Mexico | 135,267 | 17,576 | 2,395 | 16,756 | 839,470 | 26.3 | .1 | 25.1 | 47.5 |
| Oregon | 123,232 | 18,880 | 74,416 | 26,494 | 31,476 | 20.5 | 32.2 | 28.8 | 13.6 |
| South Dakota | 1,870,249 | 228,761 | 69,963 | 131,020 | 142,816 | 63.4 | 32.5 | 36.3 | 66.4 |
| Texas | 50,361 | ..... | ..... | ..... | 626,246 | ..... | ..... | ..... | 94.3 |
| Utah | 1,423 | 235 | 146 | 74 | 194 | .1 | ..... | ..... | ..... |
| Washington | 12,702 | 6,833 | 553 | 300 | 462 | 24.4 | .2 | 1.1 | .1 |
| Wyoming | 2,764 | 786 | 283 | ..... | ..... | 79.1 | 5.1 | ..... | ..... |
| Appalachian States | 31,256 | 910 | 165 | 941 | 192 | 29.2 | .1 | 30.2 | .2 |
| Total, 1916 | 11,393,838 | 964,589 | 348,177 | 1,260,172 | 14,432,378 | 21.5 | .4 | 28.1 | 18.3 |
| Value[d] | ..... | $19,939,824 | $229,097 | $26,050,067 | $9,496,505 | ..... | ..... | ..... | ..... |
| Total, 1915 | 11,878,287 | 1,084,034 | 382,459 | 1,444,077 | 16,184,924 | 22.8 | .4 | 30.4 | 22.1 |
| Value | ..... | $22,408,971 | $193,907 | $29,851,721 | $8,205,756 | ..... | ..... | ..... | ..... |

[a] Porto Rico and Philippine Islands excluded.
[b] Recovered by chlorination, 15,979.47 ounces of gold in California and 4,366.50 ounces in Colorado; and silver recovered by chlorination, 634 ounces in California and 2,150 ounces in Colorado.
[c] Represents crude ore and tailings, some of which were treated by amalgamation followed by cyanidation.
[d] Value of gold recovered by chlorination, $420,589; value of silver, $1,832.

Figures corresponding to those in this table were collected and compiled for the entire United States by the Survey for the first time in 1911, and comparison for six years can therefore now be made.

The total quantity of crude ore treated and old tailings re-treated in gold and silver mills was 11,393,838 short tons in 1916 against 11,878,287 tons in 1915, 9,849,085 tons in 1914, 9,401,856 tons in 1913, 9,677,360 tons in 1912, and 9,670,483 tons in 1911.

The great bulk of the ore treated, as shown, was milled in Alaska, California, South Dakota, Nevada, and Colorado, in the order named, and here the famous mills of the Homestake, Mother Lode, Grass Valley, Treadwell, Cripple Creek, Tonopah, and Goldfield mines are especially in evidence. Large numbers of smaller mills, however, mark the wide distribution of gold mining in these regions and in many other scattered districts.

The total yield of gold by amalgamation in the United States in 1916 was 964,589 fine ounces, valued at $19,939,824, against 1,084,034 ounces, valued at $22,408,971, in 1915. The output in 1916 was 413,033 ounces in California, 228,761 ounces in South Dakota, 165,273

ounces in Alaska, 46,346 ounces in Colorado, and 37,376 ounces in Nevada. South Dakota showed the only increase, which was a nominal one, in gold recovered by amalgamation.

The total yield of silver by amalgamation in 1916 was only 348,177 fine ounces, valued at $229,097, against 382,459 ounces, valued at $193,907, in 1915. The output came mainly from California, Oregon, South Dakota, Alaska, Nevada, and Colorado, in the order given, and consisted chiefly of silver alloyed with gold.

The total output of gold by cyanidation in 1916 was 1,260,172 fine ounces, valued at $26,050,067, against 1,444,077 ounces, valued at $29,851,721, in 1915. The output was 530,466 ounces in Colorado, 293,625 ounces in Nevada, 131,020 ounces in South Dakota, 80,337 ounces in Alaska, 63,444 ounces in Arizona, and 56,947 ounces in California in 1916.

The total silver yield by cyanidation in 1916 was 14,432,378 fine ounces, valued at $9,496,505, against 16,184,924 ounces, valued at $8,205,756, in 1915. Nevada led, with the bulk of the output—11,301,861 ounces—and was followed by New Mexico with 839,470 ounces, Arizona with 648,382 ounces, Texas with 626,246 ounces, and Colorado with 510,991 ounces. The most notable losses were in Arizona, 91,399 ounces; New Mexico, 287,276 ounces; Colorado, 59,657 ounces; Montana, 71,290 ounces; and Nevada, 1,156,900 ounces.

Of the gold-producing States, whose chief output is from milling ores, Alaska, California, and South Dakota still yield more gold by amalgamation than by cyanidation, whereas the latter process produces more gold than amalgamation in Colorado, Arizona, and Nevada, and it produces much more silver in Arizona, Colorado, Montana, Nevada, New Mexico, South Dakota, and Texas. Oregon and California were the only States in which the recovery of silver by amalgamation exceeded that by cyanidation. Altogether amalgamation produced gold and silver valued at $20,168,921 from milling ores in 1916, against $35,546,572 produced by cyanidation from such ores in that year.

Of the total output of gold from all sources in 1916, amalgamation produced 19.8 per cent in Alaska, 39.6 per cent in California, and 63.4 per cent in South Dakota, and cyanidation produced 32.9 per cent in Arizona, 57.2 per cent in Colorado, 68.4 per cent in Nevada, 25.1 per cent in New Mexico, and 36.3 per cent in South Dakota.

Of the total output of silver from all sources in 1916, amalgamation produced 32.5 per cent in South Dakota and 32.2 per cent in Oregon, and cyanidation produced 81.7 per cent in Nevada, 47.5 per cent in New Mexico, 66.4 per cent in South Dakota, and 94.3 per cent in Texas.

For details of the consumption of quicksilver in the amalgamation milling process and of potassium cyanide and sodium cyanide in the cyanidation process the reader is referred to the mines reports of the several Western States indicated in the prefatory note. Data as to consumption of these supplies are not yet furnished by a sufficient number of mining and milling companies to justify tabulation for the entire United States. It has been estimated by H. D. McCaskey that the annual consumption of quicksilver in the amalgamation process in the United States (including Alaska) for the period 1911 to 1916, inclusive, has varied between 80,000 and 100,000 pounds.

*Potassium and sodium cyanides consumed in certain Western States, 1913–1916, in pounds.*

| | Potassium cyanide. | | | | Sodium cyanide. | | | |
|---|---|---|---|---|---|---|---|---|
| | 1913 | 1914 | 1915 | 1916 | 1913 | 1914 | 1915 | 1916 |
| Arizona | | | 715 | | | | 226,427 | 216,841 |
| Colorado | 659,374 | 35,800 | 39,600 | 22,200 | 260,589 | 935,589 | 1,068,592 | 1,082,617 |
| Idaho | | | 2,894 | 3,431 | | | 3,725 | 700 |
| Montana | | | 1,003 | 13,305 | | | 162,377 | 190,249 |
| Nevada | | | 12,514 | 140,328 | | | 3,050,092 | 2,179,995 |
| New Mexico | 1,415 | | 29,000 | | 190,190 | 237,511 | 216,709 | 176,525 |
| South Dakota | 113,727 | 89,649 | 11,477 | 5,300 | 388,961 | 425,307 | 458,300 | 419,210 |
| Utah | | | 36 | 1,200 | | | 5,320 | |
| Washington | | | 1,200 | | | | 3,400 | 2,380 |
| | 774,516 | 125,449 | 99,439 | 186,264 | 839,740 | 1,598,407 | 5,214,942 | 4,268,517 |

In the following tables, compiled by V. C. Heikes, of the United States Geological Survey, some details are given for the consumption of quicksilver and of cyanide in the recovery of gold and silver in six Western States from 1911 to 1916, inclusive.

*Quicksilver consumed in certain Western States, 1911–1916.*

| State and year. | Number of mills using quicksilver. | Ore and tailings treated. | Total quicksilver.[a] | Quicksilver consumed (average per ounce of gold and silver bullion). |
|---|---|---|---|---|
| Arizona: | | *Short tons.* | *Pounds.* | *Pounds.* |
| 1911 | 26 | 46,833 | 1,362.00 | 0.086 |
| 1912 | 40 | 28,028 | 1,414.30 | .098 |
| 1913 | 18 | 36,338 | 2,912.68 | .158 |
| 1914 | 22 | 44,808 | 1,802.00 | .116 |
| 1915 | 32 | 34,360 | 547.00 | .063 |
| 1916 | 13 | 17,568 | 645.00 | .040 |
| Idaho: | | | | |
| 1911 | 35 | 72,210 | 1,648.00 | .057 |
| 1912 | 43 | 34,609 | 700.00 | .020 |
| 1913 | 40 | 28,258 | 254.00 | .019 |
| 1914 | 29 | 25,877 | 598.00 | .042 |
| 1915 | 36 | 46,423 | 1,040.00 | .027 |
| 1916 | 36 | 66,304 | 1,183.00 | .030 |
| Montana: | | | | |
| 1911 | 24 | 61,767 | 898.00 | .031 |
| 1912 | 17 | 48,837 | 783.59 | .047 |
| 1913 | 23 | 14,508 | 289.57 | .077 |
| 1914 | 18 | 29,983 | 408.00 | .074 |
| 1915 | 24 | 28,504 | 371.00 | .051 |
| 1916 | 18 | 18,959 | 206.00 | .026 |
| Nevada: | | | | |
| 1911 | 56 | 781,463 | 4,753.00 | .012 |
| 1912 | 49 | 388,714 | 6,636.73 | .044 |
| 1913 | 39 | 360,579 | 5,054.73 | .051 |
| 1914 | 42 | 250,408 | 6,826.00 | .063 |
| 1915 | 47 | 211,729 | 4,367.00 | .038 |
| 1916 | 36 | 131,891 | 2,111.00 | .034 |
| Utah: | | | | |
| 1911 | 6 | 5,020 | 105.00 | .058 |
| 1912 | 4 | 558 | 27.70 | .145 |
| 1913 | 3 | 1,157 | 71.81 | .107 |
| 1914 | 2 | 533 | 20.00 | .108 |
| 1915 | 3 | 1,399 | 30.00 | .020 |
| 1916 | 4 | 703 | 15.00 | .030 |
| Washington: | | | | |
| 1911 | 5 | 11,846 | 526.00 | .197 |
| 1912 | 9 | 4,909 | 121.00 | .043 |
| 1913 | 9 | 768 | 43.82 | .038 |
| 1914 | 5 | 2,146 | 43.00 | .039 |
| 1915 | 3 | 1,286 | 28.00 | .031 |
| 1916 | 5 | 11,495 | 317.00 | .027 |

[a] Partly estimated.

*Quicksilver consumed in certain Western States, 1911–1916*—Continued.

| State. | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Arizona | 1,362.00 | 1,414.30 | 2,912.68 | 1,802.00 | 547.00 | 645 |
| Idaho | 1,648.00 | 700.00 | 254.00 | 598.00 | 1,040.00 | 1,183 |
| Montana | 806.00 | 783.59 | 289.57 | 408.00 | 371.00 | 206 |
| Nevada | 4,753.00 | 6,636.73 | 5,054.73 | 6,826.00 | 4,367.00 | 2,111 |
| Utah | 105.00 | 27.70 | 71.81 | 20.00 | 30.00 | 15 |
| Washington | 526.00 | 121.00 | 43.82 | 43.00 | 28.00 | 317 |
| | 9,292.00 | 9,683.32 | 8,626.61 | 9,697.00 | 6,383.00 | 4,477 |

*Potassium and sodium cyanides consumed in certain Western States, 1911–1916.*

| State and year. | Number of mills using cyanidation process. | Ore and tailing treated. | Total consumption of cyanide.a | Cyanide consumed. | |
|---|---|---|---|---|---|
| | | | | Average per ton of ore and tailing. | Average per ounce of gold and silver. |
| Arizona: | | *Tons.* | *Pounds.* | *Pounds.* | *Pounds.* |
| 1911 | 9 | 152,815 | 115,877 | 0.758 | 0.919 |
| 1912 | 9 | 202,285 | 129,987 | .642 | .973 |
| 1913 | 11 | 208,591 | 189,291 | .907 | 1.138 |
| 1914 | 13 | 294,827 | 264,969 | .900 | .369 |
| 1915 | 17 | 267,639 | 227,142 | .850 | .275 |
| 1916 | 9 | 276,623 | 216,841 | .780 | .300 |
| Idaho: | | | | | |
| 1911 | 10 | 64,510 | 181,808 | 2.818 | 4.300 |
| 1912 | 5 | 54,477 | 161,156 | 2.958 | 3.360 |
| 1913 | 6 | 37,308 | 94,475 | 2.533 | 3.400 |
| 1914 | 10 | 12,094 | 32,529 | 1.800 | 2.530 |
| 1915 | 10 | 4,676 | 6,619 | 1.410 | .440 |
| 1916 | 8 | 3,409 | 4,631 | 1.33 | .38 |
| Montana: | | | | | |
| 1911 | 27 | 203,912 | 91,657 | .449 | .610 |
| 1912 | 21 | 184,487 | 93,344 | .506 | .913 |
| 1913 | 24 | 170,348 | 116,422 | .683 | .958 |
| 1914 | 13 | 192,235 | 151,738 | .789 | .921 |
| 1915 | 18 | 330,140 | 163,380 | .494 | .449 |
| 1916 | 18 | 381,560 | 203,554 | .53 | .60 |
| Nevada: | | | | | |
| 1911 | 41 | 1,083,883 | 2,352,961 | 2.170 | .313 |
| 1912 | 37 | 1,179,365 | 2,618,424 | 2.220 | .252 |
| 1913 | 29 | 1,326,793 | 2,798,224 | 2.109 | .228 |
| 1914 | 36 | 1,240,337 | 3,217,886 | 2.365 | .258 |
| 1915 | 37 | 1,479,898 | 3,063,606 | 2.070 | .239 |
| 1916 | 33 | 1,367,249 | 2,320,328 | 1.70 | .20 |
| Utah: | | | | | |
| 1911 | 6 | 268,601 | 205,041 | .763 | 1.430 |
| 1912 | 6 | 170,809 | 203,721 | 1.193 | 2.380 |
| 1913 | 6 | 81,940 | 70,238 | .857 | .956 |
| 1914 | 4 | 17,113 | 7,306 | .433 | .607 |
| 1915 | 3 | 12,064 | 5,356 | .440 | .830 |
| 1916 | 2 | 720 | 1,200 | 1.67 | 4.48 |
| Washington: | | | | | |
| 1911 | 3 | 17,381 | 9,700 | .544 | 2.605 |
| 1912 | 4 | 16,703 | 36,517 | 2.186 | .993 |
| 1913 | 2 | 20,410 | 32,090 | 1.572 | .993 |
| 1914 | 2 | 22,387 | 48,820 | 2.180 | .999 |
| 1915 | 4 | 1,746 | 4,600 | 2.600 | .916 |
| 1916 | 1 | 1,207 | 2,380 | 1.97 | 3.12 |

| State. | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Arizona | 115,877 | 129,987 | 189,291 | 264,969 | 227,142 | 216,840 |
| Idaho | 181,808 | 161,156 | 94,475 | 32,529 | 6,619 | 4,631 |
| Montana | 91,657 | 93,344 | 116,422 | 151,738 | 163,380 | 203,554 |
| Nevada | 2,352,961 | 2,618,424 | 2,798,224 | 3,217,886 | 3,063,606 | 2,320,328 |
| Utah | 205,041 | 203,721 | 70,238 | 7,306 | 5,356 | 1,200 |
| Washington | 9,700 | 36,517 | 32,090 | 48,820 | 4,600 | 2,380 |
| | 2,957,044 | 3,243,149 | 3,300,740 | 3,723,338 | 3,470,703 | 2,748,934 |

a Partly estimated.

It has not been possible to obtain a complete report showing the total consumption of potassium cyanide and sodium cyanide used in the recovery of gold and silver in the United States in 1916. If the quantity used in California, Alaska, Texas, and Oregon be added to the 4,454,781 pounds reported to have been used in other Western States the estimated total consumption was probably less than the estimated quantity, 3,000 tons, consumed in 1915.

The figures given indicate the increasing trend toward the elimination of potassium cyanide in the recovery of gold and silver. The growing scarcity of potassium cyanide necessarily increased the use of sodium cyanide, which is much cheaper. However, the cost of sodium cyanide is now greater than under normal trade conditions, and the domestic supply was barely sufficient for some time to supply the domestic consumption. As the quantity of bullion recovered was less in 1916 than in 1915, however, the quantities of quicksilver and of cyanide used were less. The quantity of cyanide used per ton of ore or tailings treated and the quantity of gold and silver recovered per pound of cyanide show considerable variations. These variations are doubtless due in part to greater efficiency in large milling plants in some of the States but are mainly caused by the difference in the character and varying metal content of the ores treated.

# ANTIMONY.

By Edson S. Bastin.

## INTRODUCTION.

The United States is dependent upon three classes of material as sources of antimony, its alloys, or compounds. (1) Antimony ore is imported from China (direct or via Japan), Bolivia (via Chile and Peru), and Mexico. Small quantities of ore are also produced in the western United States. (2) Liquated antimony sulphide, also known as "crude antimony," "needle antimony," and antimony matte, is imported in small quantity from China (in part via Japan). This material is produced by submitting the ores of the natural antimony sulphide, stibnite, to a red heat sufficient to melt but not to decompose it. The metallic sulphide is then run into molds and allowed to cool. (3) Metallic antimony, known as antimony regulus, is imported from China (direct or via Japan or Hongkong), but also produced in smaller quantity in the United States from both foreign and domestic ores.

A fourth class of material which should also be mentioned in this connection is antimonial lead carrying from 12 to 18 per cent antimony. Into this product there may enter any of the three classes of materials noted above and also lead ores, usually of the antimonial variety.

## USES.

*Peace uses.*—Metallic antimony unalloyed has few industrial uses. In the form of fine powder, known as "iron black," it is used for producing the appearance of polished steel on articles made of papier-mâché or pottery. For these purposes it is precipitated by the action of metallic zinc on an acid solution of antimony salts. Antimony alloys readily with most heavy metals, the alloy being harder than the two pure metals and also, in most cases, possessing the property of slight expansion on solidifying. Type metal is an alloy of antimony, lead, and tin; babbitt, antifriction, or bearing metal is usually an alloy of antimony, tin, and copper. Britannia metal, also known as "white metal," is an alloy of antimony, tin, and copper, with some zinc and, rarely, small quantities of other metals. It is used in making cheap domestic tableware, teapots, spoons, etc. Antimony alloys find minor utilization in battery plates, toys, cable coverings, etc. Lead-antimony alloy or hard lead is used in making acid resisting valves.

White antimony oxide, mainly the tetraoxide ($Sb_2O_4$) is used for making opaque white enamel and other sanitary ware. In this use antimony oxides compete with tin oxide. Antimony oxide, mainly trioxide, is used as a coloring agent in manufacture of glass, as it is more readily fusible than tetraoxide and does not impart opacity to the glass. Antimony oxides are further used as paint pigments.

The red sulphides of antimony are used in vulcanizing and coloring red rubber and also as paint pigments. The natural antimony trisulphide, stibnite, enters into the composition of safety matches or the compound is put on the match box.

Antimonate of lead containing an excess of lead oxide, known as "Naples yellow," is used in oil paints and in the glass and ceramic industries. The antimony salt tartar emetic (double tartrate of antimony and potassium) and antimony fluoride are employed as mordants in dyeing. Tartar emetic and antimony trioxide are employed medicinally.

*War uses.*—Antimonial lead carrying 12 to 13 per cent of antimony is employed in the manufacture of shrapnel bullets. Smaller quantities of liquated antimony sulphide are used in the primers of shells. For this last purpose it is claimed the material must carry less than 2 per cent of impurities insoluble in hydrochloric acid. Antimony sulphide as a powder is used in the charge of some shells to produce on explosion a dense white smoke which is of service in range finding.

## PRODUCTION.

The production of antimony ores in the United States in 1916 according to the best information available was about 4,500 short tons, valued at $40,580. The metallic antimony content of this material was about 1,770 short tons. The average tenor of the ore in metallic antimony was therefore about 40 per cent.

The principal producing States in order of importance were Nevada, California, Alaska, Washington, Oregon, Idaho, and Arkansas. Utah and Arizona produced insignificant amounts.

In Nevada the principal producing districts were in Humboldt Lander, and Elko counties, although minor amounts were produced in Churchill and Nye counties. The Sutherland mine near Lovelock, Humboldt County, was the principal producer. Development work was in progress at the Star Antimony mine, operated by J. M. Pine, near Battle Mountain, Lander County. Development work was in progress also at the Antimony King mine, near Austin, Lander County, operated by the Nichols-Layng Chemical Co., of San Francisco.

In California the production came mainly from Kern and Inyo counties, minor amounts being produced in San Bernardino and San Benito counties. The greater part of the output was from two mines in Inyo and Kern counties operated by the Western Metals Co., of Los Angeles, the ore being shipped to San Pedro, near Los Angeles, for smelting.

In Washington the antimony was produced at the property of the Gold Creek Antimony Mining & Smelting Co., near Methow, in Okanogan County. This property was until recently involved in litigation, and the production in 1916 was made by the unsuccessful claimants. A small production was also reported from the Wenachee district, Chelan County.

In Oregon the production came largely from Baker County, the Jim Dandy mine, near Baker City, being the principal producer. The product from this mine is understood to be mainly oxide ore. A small production of mixed stibnite and oxide ore was reported from the Palmer Creek district in Jackson County.

In Idaho the production was all from Shoshone County, although prospects are known in Blaine, Custer, and Idaho counties. The production in Shoshone County was mainly from Pine Creek, in the Yreka district.

In Arkansas one property at Gillham, Sevier County, produced a noteworthy output of ore in 1916 and also produced a small quantity of metallic antimony at a local reduction plant.

In Utah the antimony ore mined came from Box Elder County.

In Alaska the production was mainly from the Fairbanks district, with small quantities from the Nome district, the ore being shipped to Los Angeles and Seattle for smelting. The principal antimony mines in the Fairbanks district have been described in a recent report by J. B. Mertie, jr.,[1] of the United States Geological Survey, and his descriptions are quoted below:

A number of antimony mines were operated in 1916; but all of them except the Chatham mine were closed in August. Stibnite is known to have been mined at the Chatham mine, the Black Eagle mine, the Hindenburg claim, and at the Leindecker property.

One silver-lead lode, near the head of Cleary Creek, was worked by the Eldorado Mining & Milling Co.

*Chatham.*—The Chatham mine, near the head of Chatham Creek, is in reality a gold mine; but during the season of 1916 it was worked for the antimony ore which it contained and hence the 2-stamp mill on the property was idle.

The main tunnel has been driven 1,300 feet; but the present work in the mine is being done largely in a stope above the tunnel, about 850 feet from the entry. A raise has been driven 100 feet to the surface, and 60 feet above the tunnel in this raise is the stope from which the antimony ore is being removed. The vein, which is about 18 inches thick, is almost vertical and strikes N. 70° E. Several feet of gouge lies along the footwall, usually the south side of this vein, but the hanging wall is firmer. The ore is stibnite. This vein is said to cut the main gold quartz vein of the Chatham mine at an angle of 85°.

About 20 feet from the raise a shaft has been sunk 32 feet from the floor of the tunnel, striking the stibnite vein below. Mining is also being carried on at the bottom of this shaft, but pumping is necessary.

*Hindenburg.*—The Hindenburg claim, at an elevation of about 1,600 feet on the divide between Spruce and Eldorado creeks, was worked for stibnite during the summer of 1916 by Poz & Contardi, but the mine was idle at the time of the writer's visit in August. Seven or eight men were employed during the early part of the summer. It is reported that 200 tons of ore was shipped from this property.

The workings consist of a shaft 25 feet deep, with drifts from the bottom. The ore body is said to lie nearly flat, dipping about 60° SE.

*Black Eagle.*—The Black Eagle mine, on Eagle Creek, a southwesterly tributary of Treasure Creek, has been described in some detail by Brooks.[2] This property was closed and was not visited by the writer. It was the largest producer of stibnite in the district in 1916.

*Leindecker.*—On the Leindecker property, at the head of Too Much Gold Creek, no operations were in progress in August, 1916.

## IMPORTS.

The accompanying statistics of imports were taken from the reports of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, long tons being recalculated to short tons and pounds to short tons. The imports are reported as (1) imports for consumption, including merchandise entered for immediate consumption or withdrawn from bonded warehouses for consumption, and (2) total imports. Only total imports are listed by countries of origin.

[1] Mertie, J. B., jr., Lode mining in the Fairbanks district, Alaska: U. S. Geol. Survey Bull. 662, pp. 414-415, 1917.

[2] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, pp. 28-29, 1916.

In contrast to the small domestic production of antimony ore—about 4,500 short tons—the total imports in 1916 amounted to 7,764 short tons of antimony ore and 9,875 short tons of metallic antimony. In the customs classification for monthly import returns antimony matte, which is liquated sulphide, and antimony regulus, which is metallic antimony, are grouped in one class, but the quarterly returns of imports for consumption differentiate between these materials and record no imports of the matte or liquated sulphide during 1916.

Total imports in 1916 by countries of origin are shown in the accompanying table. Those credited to Chile originated in Bolivia, and those credited to Hongkong and Japan originated in China. Imports credited to the Dutch East Indies probably came from the Dutch portions of the Island of Borneo, which formerly produced a much larger quantity than at present.

*Total imports of antimony into the United States in 1916.*

| Country. | Antimony ore. | | | Antimony metal.[a] | |
|---|---|---|---|---|---|
| | Quantity (short tons). | Antimony content (pounds). | Value. | Quantity (pounds). | Value. |
| Argentina | 1 | 1,568 | $155 | ..... | ..... |
| British India | 38 | 47,703 | 8,499 | ..... | ..... |
| Canada | 38 | 61,437 | 3,628 | 12,770 | $5,207 |
| Chile[b] | 4,317 | 5,520,361 | 467,776 | ..... | ..... |
| China | 1,048 | 1,481,394 | 320,856 | 12,065,485 | 2,773,940 |
| Colombia | 2 | 4,067 | 646 | ..... | ..... |
| Dutch East Indies | 151 | 211,680 | 38,304 | ..... | ..... |
| England | 56 | 78,512 | 21,927 | 390,508 | 89,926 |
| Hongkong[c] | ..... | ..... | ..... | 300,014 | 90,540 |
| Japan[c] | ..... | ..... | ..... | 6,869,293 | 2,225,067 |
| Honduras | 10 | 10,777 | 2,378 | ..... | ..... |
| Panama | 15 | 13,784 | 1,933 | ..... | ..... |
| Mexico | 1,339 | 1,048,387 | 54,948 | ..... | ..... |
| Peru | 349 | 450,225 | 32,906 | ..... | ..... |
| Portugal | 400 | 555,528 | 96,850 | ..... | ..... |
| Spain | ..... | ..... | ..... | 111,760 | 35,205 |
| | 7,764 | 9,485,423 | 1,049,806 | 19,749,830 | 5,219,895 |

[a] May possibly include very small amounts of liquidated antimony sulphide known in the trade as "crude antimony," "antimony matte," or "needle antimony."
[b] Imports credited to Chile originated in Bolivia.
[c] Nearly all the imports of antimony ore and metal from Hongkong and Japan are of Chinese origin. Some of the material credited to other countries is possibly also of Chinese origin, having been transshipped in a foreign port.

Imports for consumption for the last five years are shown below.

*Antimony imported and entered for consumption, 1912–1916.*

| Year. | Antimony ore.[a] | | | Liquated antimony sulphide.[b] | | Metallic antimony.[c] | | Antimony oxide and other compounds.[d] | |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity (short tons). | Antimony content (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| 1912 | 1,060 | 781 | $51,444 | ..... | ..... | 6,968 | $808,473 | 880 | $81,077 |
| 1913 | 2,860 | 2,007 | 137,361 | 3 | 419 | 6,249 | 798,581 | 984 | 117,169 |
| 1914 | 1,791 | 1,254 | 71,341 | 49 | 4,004 | 6,555 | 736,420 | 1,372 | 315,001 |
| 1915 | 2,494 | 1,544 | 332,125 | ..... | ..... | 7,354 | 2,660,830 | 433 | 132,193 |
| 1916 | 7,840 | 4,622 | 1,072,340 | ..... | ..... | 7,064 | 3,548,507 | 243 | 109,532 |

[a] Classified in tariff classification as "Antimony ore and stibnite containing antimony."
[b] Classified in tariff classification as "Antimony matte, containing not more than 10 per cent of lead." Commercially known as "crude antimony" or "needle antimony."
[c] Classified in tariff classification as "Antimony regulus or metal."
[d] Classified in tariff classification as "Antimony, oxide, salts, and compounds of."

## FOREIGN DEPOSITS CONTRIBUTING TO DOMESTIC SUPPLY.

*Bolivia.*—Antimony mining in Bolivia has undergone rapid expansion since the beginning of the war. Prior to 1915 production appears not to have exceeded about 300 tons in any one year; in 1915 it rose to 17,923 tons, and in 1916, according to the American legation at La Paz, it reached 27,414 tons. Great Britain is known to have purchased large quantities of Bolivian ore, and only a small percentage of the production has come to the United States. According to the Western Metals Co., of Los Angeles, an analysis of high-grade ore from one of the principal Bolivia producers showed antimony (Sb) 66 per cent, silica ($SiO_2$) 7.25 per cent, iron oxide (FeO) 1.32 per cent, lime (CaO) 2.6 per cent, and sulphur (S) 14.04 per cent.

*China.*—Southern China has long been the principal producing district in the world for antimony ores, and at present is the main source of supply for this country. The most important deposits are in the Province of Hunan, where the largest smelting center is Changsha. According to recent advices from the United States consul at Changsha, the production of that district in 1916 was 302 tons of antimony ore and 21,347 tons of liquated sulphide and metal. The Wah Chang Mining & Smelting Co. was the principal producer.

Small quantities are produced in other districts of southern China.

According to the United States consul general[1] at Shanghai, the exports of antimony ore from China in 1916 were 81,964 tons, as against 1,843 tons in 1915, and of liquated antimony sulphide and metallic antimony (crude and regulus) 24,740 tons, as against 23,931 tons in 1915. Of the exports lumped in one classification as crude and regulus the larger part was probably crude. In 1915, for example, the exports were 10,664 short tons of crude and 2,115 short tons of regulus. The crude or liquated sulphide carries from 68 to as high as 76 per cent of antimony.

*Japan.*—Very little antimony ore is mined in Japan, but large quantities of Chinese ore are smelted there and large quantities of crude reduced to metallic form, much of the product of which comes to the United States.

*Portugal.*—Imports credited to Portugal in 1916 probably came from the Oporto and Braganza districts, where are located the principal antimony deposits of that country. The total exports of antimony ore from Portugal in 1916 were 4,330 tons.

*Peru.*—It is uncertain whether the 349 tons imported from Peru in 1916 were mined in that country or in Bolivia. According to F. C. Fuchs,[2] there has been much recent activity in antimony mining in Peru under the stimulus of high prices. The principal deposits are near the railroad to Cuzco, and most of the ore was shipped to Japan.

*Mexico.*—Imports from Mexico were mainly oxide ores from the Catorce district, in the State of San Luis Potosi, and from a point near Antimonio, close to the Gulf of California, in the State of Sonora.

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[1] Daily Trade and Consular Repts., Dec. 19, 1917.
[2] The mining industry of Peru: Eng. and Min. Jour., June 9, 1917.

The ore was shipped to the International Lead Refining Co., at East Chicago, Ind.; to the U. S. Metals Refining Co., at East Chicago, Ind.; and to the Metals Refining Co., at Hammond, Ind.

## ANTIMONY SMELTERS.

Smelting plants operating during 1916 for the production of metallic antimony from antimony ores were those of the Western Metals Co., of Los Angeles, which operated mines in Kern and Inyo counties, Cal., and also purchased ores from Alaska and elsewhere; the Chapman Smelting Co., of San Francisco, which purchased ores from many sources; the Magnolia Metal Co., of Matawan, N. J., which purchased ores from various sources; the Antimony Smelting & Refining Co., at Seattle, which produced small quantities of antimony oxides mainly from ores mined in Washington; the Nichols-Layng Chemical Co., of San Francisco.

The Chapman Smelting Co. of San Francisco, and the Antimony Smelting & Refining Co., of Seattle, have since ceased operations. Domestic antimony ores were also smelted by the following firms in connection with the production of antimonial lead: International Lead Refining Co., East Chicago, Ind.; Great Western Smelting & Refining Co., Chicago; American Smelting & Refining Co., Murray, Utah.

## PRICES.

The average New York prices for the highest grades of antimony metal for the last nine years were as follows:

*Average annual prices (cents a pound) of antimony at New York, 1908–1916.*

| | Cookson's. | Chinese and Japanese. |
|---|---|---|
| 1908 | 8.7 | ..... |
| 1909 | 8.3 | ..... |
| 1910 | 8.2 | ..... |
| 1911 | 8.6 | ..... |
| 1912 | 8.9 | ..... |
| 1913 | 8.7 | ..... |
| 1914 | 10.7 | ..... |
| 1915 | ..... | 29.6 |
| 1916 | ..... | 25.3 |

In 1914 normal prices were maintained until the outbreak of the war, when the price rose from an average of 7.2 cents in July to 17.2 in August.

The price at the beginning of 1916 was about 42 cents a pound, from which it rose to 46 cents in March and then declined steadily to about 11 cents early in October. Later there was a slight recovery to about 15 cents at the close of the year. The decline was the result of overproduction in China, which flooded the American market with the Chinese products. With these the American antimony miners soon found themselves unable to compete, and the latter part of the year witnessed a great decline in antimony mining in this country.

## LITERATURE.

A few of the more important or more recent publications dealing with antimony are listed below. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

BROOKS, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, 67 pp., 1916. 15c.

HESS, F. L., The Arkansas antimony deposits: U. S. Geol. Survey Bull. 340, pp. 241–252, 1908. 30c.

KNOPF, ADOLPH, The antimonial silver-lead veins of the Arabia district, Nev.; U. S. Geol. Survey Bull. 660, pp. 249–255, 1918.

LI, K. C., Industrial uses of antimony: Eng. and Min. Jour., vol. 104, pp. 908–909, 1917.

——— Metallurgy of antimony: Eng. and Min. Jour., vol. 104, pp. 683–689, 1917.

MALLERY, WILLARD, Antimony veins at Bernice, Nev.: Min. and Sci. Press, vol. 112, p. 556, 1916.

Occurrence and utilization of antimony ores: Imp. Inst. Bull., vol. 14, No. 3, pp. 389–417, London, 1916.

RICHARDSON, G. B., Antimony in southern Utah: U. S. Geol. Survey Bull. 340, pp. 253–256, 1908. 30c.

WANG, C. Y., Antimony: Its history, chemistry, mineralogy, geology, metallurgy, uses, preparations, analysis, production, and valuation; with complete bibliographies, 217 pp., Philadelphia, J. B. Lippincott Co., 1909.

WHEELER, A. S., Antimony production in the Hunan Province, South China: Min. and Eng. World, Apr. 8, 1916, pp. 697–699.

——— Antimony smelting in the Hunan Province, South China: Min. and Eng. World, Apr. 15, 1916, pp. 739–741.

# MANGANESE AND MANGANIFEROUS ORES.

By D. F. HEWETT.

## INTRODUCTION.

As an indication of the condition of the domestic manganese industry during 1916 it may be said that probably in no other mineral industry has there been the same inducement for change in source of supply, price, and manner of utilization. The continued elimination of established foreign sources of manganese ore and ferromanganese has caused the country to depend almost entirely on the ore deposits in Brazil. As prices of ore and ferromanganese more than doubled within the year, there has been strong incentive to utilize less desirable domestic supplies of ore. As a result, domestic production of each grade of ore in 1916 was nearly three times that of 1915. Although this is still only a small part of the country's needs as expressed in terms of manganese metal, the production is much larger than many competent observers thought possible several years ago.

The domestic shipments of manganese ore in 1916 were 26,997 gross tons; of ferruginous manganese ore, 176,130 tons; and of manganiferous iron ore, 372,673 tons.[1] Most of this material is used in the iron and steel industries.

The declaration of a blockade of England and the coasts of her allies by Germany in February, 1916, and the subsequent destruction of merchant ships have made hazardous the importation of customary quantities of ferromanganese from England and have increased the cost of obtaining ores from Brazil and India. In spite of the increased cost, Brazil supplied, in 1916, 471,837 tons of ore, about 82 per cent of all imports and nearly twice the quantity shipped in 1915. There has been an energetic search for near-by sources of ore, and as a result the deposits of Cuba were vigorously exploited and new deposits in Costa Rica and Panama became the source of small shipments.

[1] See explanation of revised classification, p. 733.

*Manganese alloys and ore produced in the United States and imported from important foreign sources, 1890–1916, in gross tons.*

| Year. | Steel. | Ferromanganese. | | Spiegeleisen. | | Manganese ore. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production. | Production. | Imports. | Production. | Imports. | Production. | Total imports. | Imports from— | | |
| | | | | | | | | Russia. | India. | Brazil. |
| 1890..... | 4,277,071 | ..... | ..... | ..... | ..... | 19,287 | 34,154 | ..... | ..... | ..... |
| 1891..... | 3,904,240 | ..... | ..... | ..... | ..... | 22,452 | 28,825 | ..... | ..... | ..... |
| 1892..... | 4,927,581 | ..... | ..... | ..... | ..... | 13,613 | 58,572 | ..... | ..... | ..... |
| 1893..... | 4,019,995 | ..... | ..... | ..... | ..... | 7,718 | 68,113 | [a] 39,070 | [b] | ..... |
| 1894..... | 4,412,032 | ..... | ..... | ..... | ..... | 6,308 | 44,055 | [a] 28,300 | ..... | [c] |
| 1895..... | 6,114,834 | ..... | ..... | ..... | ..... | 9,547 | 86,111 | [a] 55,987 | ..... | ..... |
| 1896..... | 5,281,689 | ..... | ..... | ..... | ..... | 10,088 | 31,489 | [a] 3,600 | ..... | ..... |
| 1897..... | 7,156,957 | ..... | ..... | ..... | ..... | 11,108 | 119,961 | 38,910 | 17,400 | 12,082 |
| 1898..... | 8,932,857 | ..... | ..... | ..... | ..... | 15,957 | 114,885 | 46,396 | 5,944 | 17,031 |
| 1899..... | 10,639,857 | ..... | ..... | ..... | ..... | 9,935 | 188,349 | 73,397 | 17,950 | 28,115 |
| 1900..... | 10,188,329 | [d] | [e] | [d] | [e] | 11,771 | 256,252 | 132,121 | 10,650 | 54,451 |
| 1901..... | 13,473,995 | 59,639 | 20,750 | 231,822 | 26,827 | 11,995 | 165,722 | 32,600 | 11,000 | 48,029 |
| 1902..... | 14,947,250 | 44,526 | 50,388 | 168,408 | 68,813 | 7,477 | 235,576 | 3,338 | 64,170 | 102,550 |
| 1903..... | 14,534,978 | 35,961 | 41,519 | 156,700 | 122,015 | 2,825 | 146,056 | 5,576 | 35,960 | 76,910 |
| 1904..... | 13,859,887 | 57,076 | 21,813 | 162,370 | 4,623 | 3,146 | 108,519 | 11,959 | 10,200 | 66,875 |
| 1905..... | 20,023,947 | 62,186 | 52,841 | 227,797 | 55,457 | 4,118 | 257,033 | 24,650 | 101,080 | 114,670 |
| 1906..... | 23,398,136 | 55,520 | 84,359 | 244,980 | 103,268 | 6,921 | 221,260 | 13,805 | 154,180 | 30,260 |
| 1907..... | 23,362,594 | 55,918 | 87,400 | 283,430 | 48,994 | 5,604 | 209,021 | 1,000 | 95,300 | 52,922 |
| 1908..... | 14,023,247 | 40,642 | 44,024 | 111,376 | 4,579 | 6,144 | 178,203 | 350 | 143,813 | 17,150 |
| 1909..... | 23,955,021 | 82,209 | 88,934 | 142,831 | 16,921 | 1,544 | 212,765 | 14,486 | 145,140 | 35,600 |
| 1910..... | 26,094,919 | 71,376 | 114,228 | 153,055 | 25,383 | ƒ 2,258 | 242,348 | 33,120 | 140,965 | 53,750 |
| 1911..... | 23,676,106 | ƒ 74,602 | 80,263 | ƒ 104,013 | 20,970 | ƒ 2,457 | 176,852 | 19,103 | 103,580 | 41,600 |
| 1912..... | 31,251,303 | ƒ 125,378 | 99,137 | ƒ 102,561 | 1,015 | ƒ 1,664 | 300,661 | 83,334 | 125,645 | 81,580 |
| 1913..... | 31,300,874 | ƒ 119,495 | 128,070 | ƒ 106,980 | 77 | ƒ 4,048 | 345,090 | 124,337 | 141,587 | 70,200 |
| 1914..... | 23,513,030 | ƒ 100,731 | 82,997 | ƒ 76,625 | 2,870 | ƒ 2,635 | 283,294 | 52,681 | 103,583 | 113,924 |
| 1915..... | 32,151,036 | ƒ 144,260 | 55,263 | ƒ 114,556 | 200 | ƒ 8,708 | 320,778 | ..... | 30,450 | 275,579 |
| 1916..... | 42,773,080 | ƒ 224,103 | 90,928 | ƒ 182,837 | ..... | ƒ 26,997 | 576,321 | ..... | 51,960 | 471,837 |

[a] Drake, Frank, The manganese ore industry of the Caucasus: Am. Inst. Min. Eng. Trans., vol. 28, p. 191, 1898.
[b] First shipment made from India.
[c] First shipments made from Brazil.
[d] Figures for ferromanganese and spiegeleisen combined prior to 1901.
[e] Figures for fiscal years only available prior to 1901.
ƒ Marketed production.

## SOURCES OF MANGANESE.

### MANGANESE MINERALS.

Though manganese forms a part of about one hundred minerals and is a relatively widespread element, practically all the manganese in commercial use is derived from material containing one or more of the first seven of the minerals named in the following table:

*Principal manganese minerals.*

| Mineral. | Composition. | Percentage of manganese. |
|---|---|---|
| Pollanite | $MnO_2$ | 63.2 |
| Pyrolusite | $MnO_2.n\,H_2O$ | 60–63 |
| Psilomelane | $MnO_2(MnKBa)O.n\,H_2O$ | 45–60 |
| Wad | Hydrous impure mixture of manganese oxides | 5–50 |
| Manganite | $Mn_2O_3.H_2O$ | 62.4 |
| Braunite | $3Mn_2O_3.MnO.SiO_2$ | 69 |
| Franklinite | $(Fe,Zn,Mn)O.(Fe,Mn)_2O_3$ | 10–19 |
| Rhodochrosite | $MnO.CO_2$ | 47.56 |
| Rhodonite (manganese pyroxene) | $MnO.SiO_2$ | 41.9 |
| Tephroite (manganese olivine) | $2MnO.SiO_2$ | 54.3 |
| Spessartite (manganese garnet) | $3MnO.Al_2O_3.3SiO_2$ | 33.3 |

## MANGANESE ORES.

In the preparation of statistical reports on the manganese industry the Geological Survey has recognized, since 1889, four classes of materials—Manganese ores, manganiferous iron ores, manganiferous silver ores, and manganiferous zinc residuum. This classification is based on the character of the minerals now available in the United States, which in turn depends largely on the nature of the ore deposits. It has served its purpose satisfactorily, for it includes most of the materials that have distinctive geologic associations and that at the same time by reason of composition or distribution are capable of being put to certain fairly definite uses. Thus the United States alone possesses large deposits of franklinite which, after the zinc is eliminated, yields manganiferous zinc residuum. As this mineral is mined and treated in a region adjacent to the steel-producing districts, it is smelted to spiegeleisen, which finds a ready use in making Bessemer steel. For this reason data concerning its production and consumption are interesting and valuable.

Since the entrance of the United States into the world war the well-known absence of an adequate supply of materials with high manganese content has made it desirable that statistical data concerning the supply of manganese-bearing materials be presented in such a way as to show more fully than heretofore the manganese content. In this report, therefore, all the materials, except zinc residuum, are arranged in a single table according to manganese content. As the shipments of the Leadville district have been reported separately heretofore, it will serve a purpose to continue to do so. Those materials which contain more than 40 per cent of manganese are grouped as manganese ore, and as they commonly contain some iron and less than 15 per cent of silica, they are capable of being smelted to 80 per cent ferromanganese, the grade of alloy which has become established in the steel industry. As it is possible for an ore with 40 per cent of manganese to contain as much as 30 per cent of silica, it is apparent that ores may be included in this group which can not be smelted to 80 per cent ferromanganese. Ores with more than 20 per cent of silica are rarely accepted for any purpose, however, so that it may be assumed, unless it serves a purpose to state otherwise, that practically all the material contains less than 20 per cent of silica. Heretofore, small lots of ore containing as low as 35 per cent of manganese have been included in manganese ore.

Materials containing from 15 to 40 per cent of manganese will be grouped as ferruginous manganese ore. Obviously it is possible for material with this range of manganese content to have as much as 75 per cent of silica or other substances. As there is difficulty in smelting to any manganese alloy material containing as much silica as this, and as the largest market for low-grade manganiferous ores is found in the iron industry, it may be assumed that unless otherwise indicated most of the material other than manganese is iron oxide. The lower limit of manganese is chosen at 15 per cent, for that represents approximately the lowest grade of ore from which 20 per cent spiegeleisen can be made. Actually in the United States at present 20 per cent spiegeleisen is made from ores that have less than 15 per cent of manganese by adding to the furnace charge enough material containing more than 15 per cent of manganese to make the

average of the raw ore close to that figure. Also, it is known that much material containing 20 to 25 per cent of manganese is smelted to 30 per cent spiegeleisen.

Material containing 5 to 15 per cent of manganese will be referred to as manganiferous iron ore, as the remainder is largely iron oxide. Such ores may only be smelted to 20 per cent spiegeleisen when mixed with enough ore of higher grade to make the average at least 15 per cent. Large quantities of these ores are produced in the United States at present, but they appear to be used chiefly in the manufacture of high-manganese pig iron, which has special uses or is converted to steel by the basic open-hearth process. In this process the manganese aids in eliminating sulphur but is lost in the slag itself. Heretofore, large quantities of ore from the Lake Superior region containing 1 to 5 per cent of manganese, the remainder being largely iron oxide, have been included as manganiferous iron ore, but this practice is here abandoned; such ores will hereafter be included among the iron ores.

## MANGANESE AND MANGANIFEROUS ORES.

### SHIPMENTS AND PRODUCTION.

The following tables show the shipments of manganese and manganiferous ores for 1915 and 1916:

*Manganese and manganiferous ore shipped in 1915.*

| State. | Ore containing 40 per cent of manganese or more. | | | Ore containing 15 to 40 per cent of manganese. | | | Ore containing 5 to 15 per cent of manganese. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of shippers. | Quantity (gross tons). | Value. | Number of shippers. | Quantity (gross tons). | Value. | Number of shippers. | Quantity (gross tons). | Value. |
| Alabama | 1 | 200 | (a) | | | | | | |
| Arizona: | | | | | | | | | |
| Used for fluxing | | | | 1 | 1,452 | (a) | | | |
| Used for other purposes | 1 | 339 | (a) | | | | | | |
| Arkansas | 6 | 588 | $10,013 | 4 | 3,355 | $11,864 | | | |
| California | 6 | 2,563 | 29,004 | | | | | | |
| Colorado: | | | | | | | | | |
| Used for fluxing | | | | 9 | 8,205 | 16,654 | 13 | [b] 6,760 | $2,948 |
| Used for other purposes | 1 | 150 | (a) | 4 | 15,956 | 41,527 | | | |
| Georgia | 4 | 3,168 | 33,927 | 1 | 676 | (a) | | | |
| Minnesota | | | | 3 | 38,409 | 178,843 | 1 | 4,564 | (a) |
| Nevada: | | | | | | | | | |
| Used for fluxing | | | | | | | 1 | 104,498 | (a) |
| Tennessee | | | | 1 | 150 | (a) | | | |
| Texas | 1 | (a) | (a) | | | | | | |
| Utah | 1 | (a) | (a) | 1 | 55 | (a) | | | |
| Virginia | 7 | 1,620 | 17,988 | 6 | 1,944 | 6,708 | | | |
| Wisconsin | | | | | | | 1 | 10,616 | (a) |
| Undistributed | | 80 | 17,117 | | | 14,537 | | | 549,135 |
| | 28 | 8,708 | 108,049 | 30 | 70,202 | 270,133 | 16 | [b] 126,438 | 552,083 |

[a] Included under "Undistributed." Survey not at liberty to publish.
[b] Includes 796 gross tons of ore containing less than 5 per cent manganese.

*Manganese and manganiferous ore shipped in 1916.*

| State. | Ore containing 40 per cent of manganese or more. | | | Ore containing 15 to 40 per cent of manganese. | | | Ore containing 5 to 15 per cent of manganese. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of shippers. | Quantity (gross tons). | Value. | Number of shippers. | Quantity (gross tons). | Value. | Number of shippers. | Quantity (gross tons). | Value. |
| Alabama | 1 | (a) | (a) | ..... | ..... | ..... | ..... | ..... | ..... |
| Arizona: | | | | | | | | | |
| Used for fluxing | ..... | ..... | ..... | 1 | 4,436 | $23,945 | ..... | ..... | ..... |
| Used for other purposes | 4 | 2,754 | $109,089 | 2 | 3,262 | 19,930 | ..... | ..... | ..... |
| Arkansas | 10 | 6,131 | 176,995 | 7 | 3,869 | 26,392 | ..... | ..... | ..... |
| California | 5 | 6,054 | 122,409 | 2 | 221 | (c) | ..... | ..... | ..... |
| Colorado: | | | | | | | | | |
| Used for fluxing | ..... | ..... | ..... | 9 | 6,025 | 15,551 | 13 | b 10,238 | $3,464 |
| Used for other purposes | 3 | 110 | 1,670 | (c) | 90,850 | 299,012 | ..... | ..... | ..... |
| Georgia | 1 | (a) | (a) | 2 | (a) | (a) | ..... | ..... | ..... |
| Minnesota | ..... | ..... | ..... | 2 | 37,710 | (a) | 6 | 202,693 | 669,133 |
| Montana | 5 | 3,268 | 25,378 | 2 | (a) | (a) | ..... | ..... | ..... |
| Nevada: | | | | | | | | | |
| Used for fluxing | ..... | ..... | ..... | ..... | ..... | ..... | 1 | 122,429 | (a) |
| Used for other purposes | 1 | (a) | (a) | ..... | ..... | ..... | ..... | ..... | ..... |
| New Mexico | ..... | ..... | ..... | 3 | 16,574 | 47,966 | ..... | ..... | ..... |
| Pennsylvania | ..... | ..... | ..... | ..... | ..... | ..... | 1 | 451 | (a) |
| Tennessee | 3 | 212 | 5,459 | 2 | (a) | (a) | ..... | ..... | ..... |
| Texas | 1 | (a) | (a) | ..... | ..... | ..... | ..... | ..... | ..... |
| Utah | 6 | 1,282 | 22,597 | 2 | (a) | (a) | ..... | ..... | ..... |
| Virginia | 14 | 4,388 | 118,139 | 7 | 5,242 | 22,282 | 3 | 32,487 | 82,715 |
| Washington | 1 | (a) | (a) | ..... | ..... | ..... | 1 | (a) | (a) |
| Wisconsin | ..... | ..... | ..... | ..... | ..... | ..... | 1 | 3,982 | 6,570 |
| Undistributed | ..... | 2,798 | 45,681 | ..... | 7,941 | 179,042 | ..... | 393 | 609,489 |
| | 55 | 26,997 | 627,417 | (c) | 176,130 | 634,120 | 26 | b 372,673 | 1,371,371 |

a Included under "Undistributed," Survey not at liberty to publish.
b Includes 1,026 gross tons of ore containing less than 5 per cent manganese.
c Not ascertained.

*Manganese and manganiferous ore produced in the United States, 1838 to 1916, in gross tons.*[a]

| Year. | Ore containing 40 per cent of manganese or more. | Ore containing 15 to 40 per cent of manganese. | Ore containing 5 to 15 per cent of manganese. | Year. | Ore containing 40 per cent of manganese or more. | Ore containing 15 to 40 per cent of manganese. | Ore containing 5 to 15 per cent of manganese. |
|---|---|---|---|---|---|---|---|
| 1838-1879 | 43,860 | ..... | ..... | 1899 | 9,935 | (b) | |
| 1880 | 5,761 | ..... | ..... | 1900 | 11,771 | (b) | |
| 1881 | 4,895 | ..... | ..... | 1901 | 11,995 | (b) | |
| 1882 | 4,532 | ..... | ..... | 1902 | 7,477 | (b) | |
| 1883 | 6,155 | ..... | ..... | 1903 | 2,825 | (b) | |
| 1884 | 10,180 | ..... | ..... | 1904 | 3,146 | (b) | |
| 1885 | 23,258 | (b) | | 1905 | 4,118 | (b) | |
| 1886 | 30,193 | (b) | | 1906 | 6,921 | 41,300 | |
| 1887 | 34,524 | (b) | | 1907 | 5,604 | 103,844 | |
| 1888 | 29,198 | (b) | | 1908 | 6,144 | 55,894 | |
| 1889 | 24,197 | (b) | | 1909 | 1,544 | 68,654 | |
| 1890 | 19,287 | (b) | | 1910 | 2,258 | 61,101 | |
| 1891 | 22,452 | (b) | | 1911 | 2,457 | 44,437 | |
| 1892 | 13,613 | (b) | | 1912 | 1,664 | 51,517 | |
| 1893 | 7,718 | (b) | | 1913 | 4,048 | 59,403 | |
| 1894 | 6,308 | (b) | | 1914 | 2,635 | 98,265 | |
| 1895 | 9,547 | (b) | | 1915 | 8,708 | 70,202 | c 126,438 |
| 1896 | 10,088 | (b) | | 1916 | 26,997 | 176,130 | d 372,673 |
| 1897 | 11,108 | (b) | | | | | |
| 1898 | 15,957 | (b) | | | 453,078 | | |

a Beginning with 1910, the figures represent ore marketed (or shipments).
b Manganiferous ore included in iron ore figures.
c Includes 796 tons of ore containing less than 5 per cent manganese.
d Includes 1,026 tons of ore containing less than 5 per cent manganese.

## MANGANESE ORE.

### PRODUCTION.

The production of ores containing 40 per cent of manganese or more in 1916 was 26,997 tons, valued at $627,417, or slightly more than three times the production of 1915, which was 8,708 tons, valued at $108,049. The value of the shipments in 1916 was therefore almost six times that of 1915.

The greatest increase in production came from the mines of the Batesville district, Ark., but great increase may be noted also in California and Montana, for no shipments were made from Montana in 1915. The shipments from Montana in 1916 were derived entirely from the Philipsburg district, Granite County. The increase in shipments from Arizona came largely from the Tombstone district, Cochise County, but the Bisbee district and several others contributed. In Virginia shipments in 1916 were more than twice those of 1915, and the number of shippers also doubled. The shipments from Washington were the first recorded from that State.

Reports were received from 155 operators, a slight increase over 1915.

### IMPORTS.

The following table was compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce:

*Manganese ore imported into the United States, 1913–1916.*

| | 1913 | | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| Australia | | | | | | | 488 | $19,313 |
| Belgium | | | 450 | $5,913 | | | | |
| Brazil | 70,200 | $445,680 | 113,924 | 736,769 | 275,579 | $2,240,837 | 471,837 | 7,139,821 |
| British India | 141,587 | 710,024 | 103,583 | 504,981 | 36,450 | 194,626 | 51,960 | 401,779 |
| Canada | 5 | 631 | 64 | 1,357 | 325 | 12,989 | 756 | 72,496 |
| Chile | | | | | | | | 18 |
| Costa Rica | | | | | | | 1,244 | 38,703 |
| Cuba | | | | | 5,141 | 69,453 | 30,563 | 514,184 |
| France | 1,114 | 12,578 | 5 | 1,580 | | | | |
| Germany | 2,014 | 103,612 | 1,713 | 92,273 | 258 | 23,590 | | 16 |
| Greece | | | | | | | 3,000 | 24,318 |
| Japan | 3 | 78 | 40 | 1,320 | 2,810 | 106,434 | 5,196 | 163,491 |
| Mexico | | | | | | | 390 | 7,093 |
| Netherlands | | | 2,505 | 52,213 | 50 | 1,792 | | |
| Panama | | | | | | | 10,498 | 265,772 |
| Portugal | | | | | | | 289 | 11,997 |
| Russia | 124,337 | 712,324 | 52,681 | 490,331 | | | | |
| United Kingdom | 227 | 12,082 | 8,321 | 136,206 | 49 | 4,730 | 100 | 7,178 |
| All other | 5,603 | 32,671 | 8 | 1,177 | 116 | 1,529 | | |
| | 345,090 | 2,029,680 | 283,294 | 2,024,120 | 320,778 | 2,655,980 | 576,321 | 8,666,179 |

### PRODUCTION IN PRINCIPAL PRODUCING COUNTRIES.

The following table gives the latest available statistics with regard to American and foreign production of manganese ore.

So far as possible the figures are taken from the official publication of the country concerned, which is the case with Canada, Bel-

gium, France, German Empire, India, Italy, and Spain; otherwise, Mines and Quarries, London, is used. The Geological Survey receives assistance in its foreign statistics from Mineral Industry, New York.

*Manganese ore produced in principal producing countries, 1911–1916, in gross tons.*

| Country. | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| North America: | | | | | | |
| Canada | 5 | 67 | ..... | 25 | 180 | [a] 874 |
| Cuba [b] | ..... | ..... | ..... | ..... | 9,000 | 33,120 |
| United States | 2,457 | 1,664 | 4,048 | 2,635 | 8,708 | 26,997 |
| South America: | | | | | | |
| Brazil [c] | 171,172 | 152,431 | 120,368 | 180,738 | 284,111 | 495,172 |
| Europe: | | | | | | |
| Austria | 15,703 | 12,275 | 16,280 | [d] | [d] | [d] |
| Bosnia and Herzegovina | 3,543 | 4,577 | 5,709 | 4,055 | [d] | [d] |
| France | 5,906 | 5,488 | 7,610 | [d] | [d] | [d] |
| German Empire | 85,921 | [e] | [f] 748 | [d] | [d] | [d] |
| Greece | 721 | 7,595 | ..... | ..... | [d] | [d] |
| Hungary | 14,523 | 10,662 | 18,706 | [d] | [d] | [d] |
| Italy | 3,460 | 2,599 | 1,596 | 1,623 | [g] 12,379 | [d] |
| Russia | [h] 572,028 | [h] 911,742 | 1,289,370 | [h] 703,762 | [h] 8,705 | [h] 8,722 |
| Spain | 5,519 | 17,126 | 21,254 | 12,947 | 14,102 | [i] 13,954 |
| Sweden | 5,347 | 5,082 | 3,938 | 3,585 | 7,487 | [d] |
| United Kingdom | 4,987 | 4,170 | 5,393 | 3,437 | 4,640 | 5,140 |
| Asia: | | | | | | |
| India | 670,290 | 633,080 | 815,047 | 682,898 | 450,436 | [d] |
| Japan | 9,615 | 11,862 | 18,016 | [j] 16,807 | [j] 25,400 | [j] 7,749 |
| Africa: | | | | | | |
| Cape Colony | [c] 116 | ..... | [d] | [d] | [d] | [d] |
| Oceania: | | | | | | |
| Australia | 1,151 | 328 | 27 | 6 | 200 | [d] |

[a] Preliminary estimate.
[b] Figures collected by U. S. Geological Survey.
[c] Exports.
[d] Statistics not yet available.
[e] Statistics not available for Empire. Prussia produced 91,018 gross tons.
[f] Ore with 30+ per cent manganese, 748 gross tons; ore with 12 to 30 per cent manganese, 324,823 gross tons.
[g] Ore with 18 to 45 per cent manganese.
[h] Exports from Poti and Batum. Shipments from Tchiaturi district, Kutais province, were 703,269 gross tons in 1914; 31,470 tons in 1915, and 117,800 tons in 1916.
[i] Ore with 29 to 50 per cent manganese.
[j] 1914 and 1915: Mineral Industry; 1916: reported by J. M. Clements.

## FERRUGINOUS MANGANESE ORES.

The shipments of ore containing 15 to 40 per cent of manganese in 1916 were 176,130 tons, valued at $634,120. The quantity was about two and one-half times that shipped in 1915 (70,202 tons) and the value was slightly less than two and one-half times that in 1915 ($270,133).

The largest increase in shipments in 1916, compared with 1915, came from the Leadville district, Colo., where the shipments were the greatest on record. It should be noted also that little of this material was sent to lead smelters to be used as flux as heretofore, but most was sent to iron works to be converted to spiegeleisen. Large quantities of ore of this grade were shipped for the first time from the Silver City district, Grant County, N. Mex., for a similar purpose. Shipments from Virginia, Arizona, and Arkansas were larger in 1916 than in 1915. Shipments of this grade from Minnesota, mainly from the Cuyuna range, showed a slight decrease.

The number of shippers in 1916 was much larger than in 1915.

The increase in shipments of ore of this grade not only shows the capacity of the mines to produce but the existence of markets that were not known several years ago. In 1910 of the 61,101 tons of such ore produced 55,770 tons was used as flux, whereas in 1916 of

176,130 tons produced only 10,461 tons was so used. A large part of the difference, 165,669 tons, found its way into the iron industry, and most of it was used to make speigeleisen.

*Manganiferous silver ore shipped, 1907–1916, in gross tons.*

| Year. | Arizona. | Colorado. | Nevada. | Utah. |
|---|---|---|---|---|
| 1907 | ..... | 99,711 | ..... | ..... |
| 1908 | ..... | 51,554 | ..... | ..... |
| 1909 | ..... | 65,024 | ..... | ..... |
| 1910 | ..... | 55,770 | ..... | ..... |
| 1911 | ..... | 41,753 | ..... | ..... |
| 1912 | ..... | 48,618 | ..... | ..... |
| 1913 | ..... | 49,753 | ..... | ..... |
| 1914 | ..... | 39,881 | ..... | ..... |
| 1915 | 1,791 | 30,921 | 104,498 | ..... |
| 1916 | 10,452 | 106,863 | 122,429 | 174 |

## MANGANIFEROUS IRON ORE.

The shipments of ore containing 5 to 15 per cent of manganese in 1916 amounted to 372,673 tons, valued at $1,371,371. This quantity was almost three times that shipped in 1915—126,438 tons, valued at $552,083.

Almost all the increase in shipments came from the Cuyuna district, Minn., where the number of shippers rose from 1 to 5. Virginia, which has not recently produced ore of this grade, shipped 32,487 tons.

*Manganiferous iron ores shipped from the Cuyuna district, Minn., 1913–1916, in gross tons.*

| Mine. | Ore containing 15 to 40 per cent of manganese. | | | | Ore containing 5 to 15 per cent of manganese. | | | | Total. |
|---|---|---|---|---|---|---|---|---|---|
| | 1913 | 1914 | 1915 | 1916 | 1913 | 1914 | 1915 | 1916 | |
| Algoma (Hoch) | ..... | 192 | 3,036 | 23,000 | ..... | ..... | 4,564 | ..... | 30,792 |
| Cuyuna Mille Lacs | a26,200 | 55,000 | 35,221 | ..... | ..... | ..... | ..... | 90,000 | 206,421 |
| Ferro | ..... | ..... | ..... | 14,710 | ..... | ..... | ..... | ..... | 14,710 |
| Hillcrest | ..... | ..... | ..... | ..... | ..... | ..... | ..... | a 2,712 | 2,712 |
| Mahnomen | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 43,000 | 43,000 |
| Mangan, Nos. 1 and 2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 30,329 | 30,329 |
| Sultana | ..... | ..... | 152 | ..... | ..... | ..... | ..... | 35,218 | 35,370 |
| | 26,200 | 55,192 | 38,409 | 37,710 | ..... | ..... | 4,564 | 201,259 | 363,334 |

a Percentage of manganese not stated.

## VALUE OF MANGANESE ORES.

In general the value of materials that contain manganese depends on the composition, the minerals present, and the condition or state of aggregation of the material. The value depends largely, of course, on the content of metallic manganese, but incidentally on the absence of such substances as phosphorus, silica, copper, cobalt, and iron. For certain purposes, other things being equal, it depends on the amount of oxygen which will be liberated under certain conditions, and this is different for the several oxidized minerals. If manganese alloys are to be produced in the blast furnace, the material should be

in coherent lumps, as fine sand and powder can not be treated to advantage. On the other hand, if the material is to be used to make dry batteries or flint glass and is not already in finely divided condition, it is crushed and pulverized.

The price offered for ore to be used to make ferromanganese is normally determined by the condition of the steel industry and in the United States this price corresponds closely to that on the English, French, Belgian, and German markets when allowance is made for the difference in freight rates between the mines and the place of delivery. This is true because the furnaces of these countries derive most of their ore from the same countries that supply the United States. Since 1914, however, Russia, being unable to ship ore by sea, has produced only small quantities of ore. India, being remote and hindered by high freight rates, is at a great disadvantage and has likewise produced only small quantities of ore. Under the recent extraordinary demand for steel, Brazil, having a temporary monopoly of the market, has been able to obtain rather arbitrary prices, which in 1916 ranged from two to three times those prevailing in 1913. On the other hand, as the war has not created a similar increase in demand for dry batteries, the price of the manganese ore used to make them was only about twice the normal, in spite of the fact that prior to 1914 only Russian ore was used for this purpose and in 1916 Russian ore was no longer obtainable.

As the market for manganese ore used to make ferroalloys is well established, there are specifications governing the prices paid. The prevailing specification is that of the Carnegie Steel Co., of Pittsburgh, Pa., and prices are revised from time to time. The prices offered by this company, in August, 1916, are given below:

Schedule of prices paid per ton of 2,240 pounds for domestic manganese ore delivered at Pittsburgh or Bessemer, Pa., and South Chicago, Ill.

Prices are based on ores containing not more than 8 per cent silica or 0.20 per cent phosphorus and are subject to deductions as follows: For each 1 per cent in excess of 8 per cent silica there shall be a deduction of 15 cents per ton; fractions in proportion.

For each 0.02 per cent, or fraction thereof, in excess of 0.20 per cent phosphorus there shall be a deduction of 2 cents per unit of manganese per ton.

Ores containing less than 40 per cent manganese or more than 12 per cent silica or 0.225 per cent phosphorus are subject to acceptance or refusal at the buyer's option.

Settlements are based on analysis of sample dried at 212° F., the percentage of moisture in the sample as taken being deducted from the weight.

| Percentage of metallic manganese in ore. | Price per unit of manganese, in cents. |
|---|---|
| Over 49 | 55 |
| 46 to 49 | 53 |
| 43 to 46 | 50 |
| 40 to 43 | 46 |

According to these specifications the price paid for ores ranged from $18.40 for 40 per cent ore to $27.50 for 50 per cent ore. Some mine operators report that prices slightly higher than those indicated by the schedule were obtained from time to time during 1916.

The value of an ore adapted to use as an oxidizer in dry batteries and flint glass varies with its content of manganese dioxide, and in contradistinction to those used in metallurgical industries does not

depend, except indirectly, on its content of metallic manganese. As much of the ore of the Caucasus region contains from 85 to 92 per cent of manganese dioxide and less than 1 per cent iron and is therefore admirably adapted to these uses, most specifications for ores to be put to these uses before the war were such as could be met by ore from the Caucasus region but only rarely by ores from other regions. According to one manufacturer of dry batteries, as long as Caucasian ore was available there was little experimentation to determine the suitability of the several manganese minerals and the limits beyond which other elements than manganese may be present. As a result of recent experiments, it has been shown that copper, nickel, and cobalt are the most harmful elements in the ordinary dry battery and should not be present in even minute quantities. A few tenths of 1 per cent of any of these elements renders an ore unfit for this use. On the other hand, it is stated that more than several per cent of iron as oxide does not greatly affect the efficiency of a battery and that the 1 per cent limit is arbitrary. In the absence of an established schedule such as exists in the steel industry, most of the ore is supplied to the dry-battery makers by brokers in lots ranging from 5 to 100 tons under guaranteed specifications. On account of the temporary elimination of Caucasian ore prices have risen, and it is reported that during 1916 prices ranged from $65 to $85 a ton. Few of the known deposits of the United States are capable of producing more than a small quantity of ore that contains less than 1 per cent iron and a trace of copper, nickel, and cobalt. It was reported early in 1917 that ore containing no more than 70 per cent of manganese dioxide was marketable for these uses. It is estimated that the present demand for manganese ore for dry batteries and flint glass is about 25,000 tons a year.

The value of ferruginous manganese ores, manganiferous iron ores, and manganiferous silver ores depends on local conditions in the metallurgic industries that consume them, as the manganese content is used only indirectly. In both Minnesota and Colorado it is customary to pay a flat rate for ore having a certain percentage of manganese, iron, silica, moisture, and phosphorus. For each additional per cent of manganese a premium is paid, and for each additional per cent of silica or moisture a penalty is charged. Thus, during 1916, as one shipper in the Leadville district reports, $2.75 a gross ton was offered at the mine for ore containing 25 per cent of manganese and 25 per cent of iron; a premium of 8 cents a ton was added for each per cent of manganese in excess of 25 per cent; and further, a deduction of 4 cents a ton was made for each per cent of iron less than 25 per cent, of 3 cents a ton for each per cent of silica over 8 per cent, and of 3 cents a ton for each per cent of moisture over 12 per cent. Thus an ore containing 29 per cent of manganese, 17.5 per cent of iron, 12 per cent of silica, and 20 per cent of moisture was worth $2.41 a ton.

Ferruginous manganese ores containing 15 to 35 per cent of manganese, less than 15 per cent of silica, and the remainder chiefly iron were sold at the mines in 1916 at prices that ranged from $3.50 to $10 a ton.

Manganiferous zinc residuum is not sold in the open market but is smelted to spiegeleisen by the only company that produces it.

## MANGANIFEROUS ZINC RESIDUUM.

Unique deposits of zinc ore containing franklinite, willemite, zincite, calcite, and minor silicate and other minerals occur near Franklin Furnace, N. J. By mechanical and electromagnetic processes of separation three products are obtained from these ores, one containing the greater part of the franklinite and the remaining two the other zinc minerals. The franklinite product is first roasted with anthracite to eliminate the zinc, which is recovered as zinc oxide, and the residue, containing 14 per cent of manganese and 40 per cent of iron, is smelted to spiegeleisen.

The production of manganiferous residuum was approximately constant from 1911 to 1914, but during 1915 and 1916, large increases were recorded. No price is given for this material as it is not sold in the open market, but it is reduced to spiegelsisen by the company that produces it. The production from 1889 to 1916 is given in the following table:

*Manganiferous residuum produced from zinc roasting in the United States, 1889–1916.*

| | Gross tons. | | Gross tons. | | Gross tons. |
|---|---|---|---|---|---|
| 1889 | 43,648 | 1899 | 65,010 | 1909 | 141,264 |
| 1890 | 48,560 | 1900 | 87,110 | 1910 | 137,173 |
| 1891 | 38,228 | 1901 | 52,311 | 1911 | 109,296 |
| 1892 | 31,859 | 1902 | 65,246 | 1912 | 104,670 |
| 1893 | 37,512 | 1903 | 73,264 | 1913 | 102,239 |
| 1894 | 26,981 | 1904 | 68,189 | 1914 | 100,198 |
| 1895 | 43,249 | 1905 | 90,289 | 1915 | 159,318 |
| 1896 | 44,953 | 1906 | 93,461 | 1916 | 198,817 |
| 1897 | 33,924 | 1907 | 93,413 | | |
| 1898 | 48,502 | 1908 | 110,225 | | 2,248,909 |

NOTE.—The manufacture of spiegeleisen from manganiferous residuum was begun in 1870, but there is no record of the quantity of raw material used prior to 1889.

## FERROMANGANESE AND SPIEGELEISEN.[1]

The inability of the United States to import the customary quantity of ferromanganese from Europe since 1914 has caused not only larger importation of ore but also increased domestic smelting of the ores to ferromanganese. Fortunately, this alloy as well as spiegeleisen may be produced in common types of blast furnace with which the iron industry was already equipped. In addition, smelting of ferromanganese in the electric furnace has become established and contributes to the supply of this alloy.

During 1916 there were 224,103 tons of domestic ferromanganese and 182,837 tons of domestic spiegeleisen marketed in the United States. If the imports of ferromanganese, 90,928 tons, are added, the visible supply of this alloy for the year was 315,031 tons. The consumption can not be determined, as stocks at the beginning and the end of the year were not reported. No spiegeleisen was imported in 1916.

The firms that made ferromanganese and spiegeleisen in 1916 are listed below (f indicates ferromanganese; s, spiegeleisen). It may be

[1] Wilcox, F. H., The significance of manganese in American steel metallurgy: Am. Inst. Min. Eng. Trans., vol. 54, pp. 412–420, 1916.
Anderson, R. J., Ferromanganese in the iron and steel industry: Franklin Inst. Jour., vol. 183, pp. 579–592, 1917.
Anderson, R. J., Metallurgy of ferromanganese: Iron Trade Rev., vol. 60, p. 2, 1917.

noted that whereas ferromanganese was made at 9 plants in 1915, it was made at 14 plants in 1916; similarly, spiegeleisen was made at 7 plants in 1915 and at 12 plants in 1916.

fs American Manganese Manufacturing Co., Dunbar, Pa.
fs Berkshire Iron Works, Sheridan, Pa.
fs Bethlehem Steel Co., Sparrows Point, Md., and Lebanon, Pa.
s Colorado Fuel & Iron Co., Pueblo, Colo.
f Electric Reduction Co., Washington, Pa.
f Jones & Laughlin Steel Co., Kittanning, Pa.
fs Juniata Furnace & Foundry Co., Newport, Pa.
f Lackawanna Iron & Steel Co., Lebanon, Pa.
fs Lebanon Blast Furnace Co., Lebanon, Pa.
f Miami Metals Co., South Chicago, Ill.
s New Jersey Zinc Co., Palmerton, Pa.
f Noble Electric Steel Co., Heroult, Cal.
fs Tennessee Coal, Iron & Railroad Co., Bessemer and Birmingham, Ala.
fs United States Steel Corporation, Chicago, Ill., and Pittsburgh, Pa.

*Ferromanganese and spiegeleisen produced[a] in the United States, 1901–1916.*

| Year. | Ferromanganese. | | Spiegeleisen. | |
|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| 1901 | 59,639 | [b] | 231,822 | [b] |
| 1902 | 44,526 | [b] | 168,408 | [b] |
| 1903 | 35,961 | [b] | 156,700 | [b] |
| 1904 | 57,076 | [b] | 162,370 | [b] |
| 1905 | 62,186 | [b] | 227,797 | [b] |
| 1906 | 55,520 | [b] | 244,980 | [b] |
| 1907 | 55,918 | [b] | 283,430 | [b] |
| 1908 | 40,642 | [b] | 111,376 | [b] |
| 1909 | 82,209 | [b] | 142,831 | [b] |
| 1910 | 71,376 | [b] | 153,055 | [b] |
| 1911 | 74,602 | [c] $4,746,541 | 104,013 | [c] |
| 1912 | 125,378 | [c] 8,282,006 | 102,561 | [c] |
| 1913 | 119,495 | [c] 9,272,269 | 106,980 | [c] |
| 1914 | 100,731 | 4,440,253 | 76,925 | $1,596,139 |
| 1915 | 144,260 | 9,253,443 | 114,556 | 2,403,550 |
| 1916 | 224,103 | 30,123,493 | 182,837 | 6,158,202 |

[a] Beginning with 1911 the figures represent product marketed (or shipped).
[b] Figures not available.
[c] Value for spiegeleisen included with that for ferromanganese.

*Ferromanganese and spiegeleisen imported for consumption in the United States, 1903–1916.*

| Year. | Ferromanganese. | | Spiegeleisen. | | Total. | |
|---|---|---|---|---|---|---|
| | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. | Quantity (gross tons). | Value. |
| 1903 | 41,519 | $1,699,656 | 122,015 | $2,709,317 | 163,534 | $4,408,983 |
| 1904 | 21,813 | 707,037 | 4,623 | 132,461 | 26,436 | 839,498 |
| 1905 | 52,841 | 1,884,651 | 55,457 | 1,336,104 | 108,298 | 3,220,755 |
| 1906 | 84,359 | 4,953,944 | 103,268 | 2,942,940 | 187,627 | 7,896,584 |
| 1907 | 87,400 | 5,354,656 | 48,994 | 1,399,381 | 136,394 | 6,754,037 |
| 1908 | 44,624 | 1,860,664 | 4,579 | 125,054 | 49,203 | 1,985,718 |
| 1909 | 88,934 | 3,396,381 | 16,921 | 356,447 | 105,855 | 3,752,828 |
| 1910 | 114,228 | 4,341,071 | 25,383 | 489,049 | 139,611 | 4,830,120 |
| 1911 | 80,263 | 3,015,062 | 20,970 | 405,444 | 101,233 | 3,420,506 |
| 1912 | 99,137 | 3,906,920 | 1,015 | 28,094 | 100,152 | 3,935,014 |
| 1913 | 128,070 | 5,682,915 | 77 | 2,173 | 128,147 | 5,685,088 |
| 1914 | 82,997 | 3,619,607 | 2,870 | 71,147 | 85,867 | 3,690,754 |
| 1915 | 55,263 | 3,333,099 | 200 | 5,110 | 55,463 | 3,338,809 |
| 1916 | 90,928 | 9,240,528 | ..... | ..... | 90,928 | 9,240,528 |
| | 1,072,376 | 52,996,501 | 406,372 | 10,002,721 | 1,478,748 | 62,999,222 |

The contract price for 80 per cent ferromanganese [1] from 1912 to 1916 is well shown in the diagram presented herewith.

It will be noted that the price for ferromanganese rose suddenly in February, 1916, when Germany announced the blockade of English and allied countries, from $100 to $175 a ton and receded to $155 in November. On the other hand, the price for material for prompt delivery, which always commands a slightly higher price, rose from $150 a ton in January to $450 a ton for small lots in April.[1] During the remainder of the year the price receded and at the end of the year it was $165 a ton.

The contract price for 20 per cent spiegeleisen did not fluctuate so much, but rose rather steadily from $40 a ton in February to $60 in March and $70 in the later part of the year.

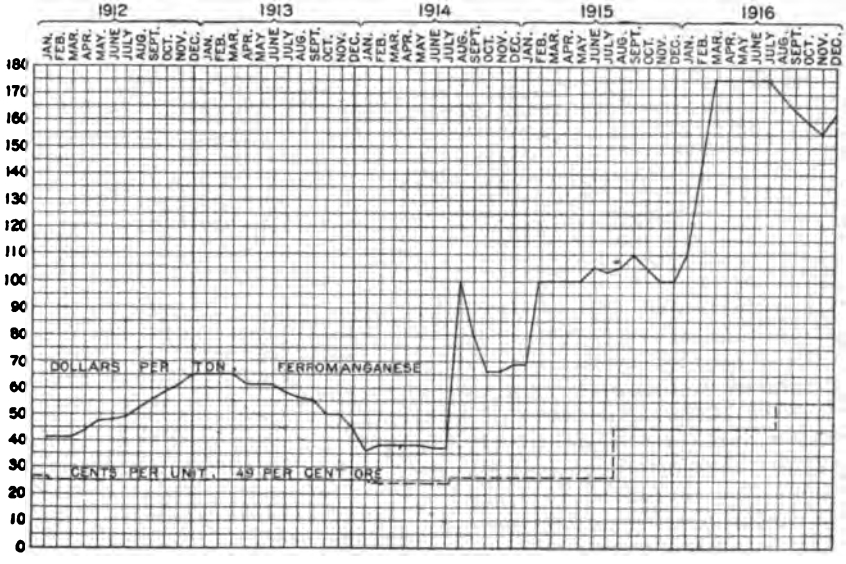


FIGURE 9.—Diagram showing contract prices for ferromanganese and manganese ore, 1912–1916.

During the decade prior to 1914 practice in making steel established the market for the two alloys, ferromanganese and spiegeleisen, which were made to meet definite specifications. Thus ferromanganese containing 80 per cent of manganese, 12 per cent of iron, and 6 to 7 per cent of carbon was used in making most grades of low-carbon steel by the open-hearth process, and spiegeleisen containing 18 to 22 per cent of manganese, 72 to 75 per cent of iron, and 4 to 5 per cent of carbon was used in making those grades of medium to high-carbon steel that could be made by the Bessemer process.

The following table has been prepared in the effort to determine whether the quantities of ferromanganese and spiegeleisen that are used in making steel have changed during recent years. The table shows the production of open-hearth and Bessemer steel, the production plus imports of ferromanganese and spiegeleisen, and the

[1] Iron Trade Rev., vol. 60, p. 25, 1917.

quantities of these alloys apparently consumed per ton of each class of steel in three five-year periods from 1901 to 1915 and in 1916. Although the difference in stocks at the beginning and end of each period and the production of manganese steel in which ferromanganese is used are not known, there can be little doubt that the table shows a striking decrease during recent years in the quantity of ferromanganese and spiegeleisen used in making steel. How far it may be possible to decrease the use of manganese alloys in making steel is a matter for metallurgists to determine, but in the present condition of the manganese industry this problem offers a splendid field for research.

*Apparent domestic consumption of ferromanganese and spiegeleisen per ton of steel, 1901–1916.*

| Period. | Open-hearth steel. | Ferromanganese. | | Bessemer steel. | Spiegeleisen. | |
|---|---|---|---|---|---|---|
| | | Production and imports. | Consumed per ton of steel. | | Production and imports. | Consumed per ton of steel. |
| | *Gross tons.* | *Gross tons.* | *Pounds.* | *Gross tons.* | *Gross tons.* | *Pounds.* |
| 1901–1905 | 31,053,491 | 446,699 | 32.2 | 45,245,009 | 1,224,832 | 60.6 |
| 1906–1910 | 61,365,323 | 725,210 | 26.5 | 48,803,689 | 1,134,817 | 52.1 |
| 1911–1915 | 98,833,090 | 1,010,196 | 22.9 | 42,329,520 | 529,867 | 28.0 |
| 1916 | 31,415,427 | 315,031 | 22.5 | 11,059,039 | 182,837 | 37.0 |

Small quantities of silico-spiegel, containing 20 to 30 per cent manganese, 5 to 15 per cent of silicon, 60 to 70 per cent of iron, and 1.4 to 4 per cent of carbon, and silico-manganese containing 60 to 75 per cent of manganese, 25 per cent of silicon, remaining 55 to of iron, and less than 2 per cent of carbon were used to 20 per cent special uses, but the demand for them was slight. produced in 1916 for

The lack of imported ore and alloys established grade and the consequent rise in prices, together with the inability of domestic deposits to supply high-grade ore, has led some enterprising steel makers to experiment with alloys containing from 30 to 60 per cent of manganese, as well as with substitute alloys. Doubtless substitutes can be used, in part at least, for certain grades of steel,[1] and it is reported that one company has been able so to change its practice as to use 32 per cent spiegeleisen instead of 80 per cent ferromanganese, as heretofore, in making steel for rails, wire, and nails by the open-hearth process.

It still remains to be determined to what extent good grades of mild steel for various uses may be made by slight variations of present practice or by the use of manganese alloys which may contain from 20 to 80 per cent of manganese and which may be made from the ore known to exist in the United States. Until experiments on a working scale have been made, there will be little incentive to produce new grades of alloys, as the few recent attempts of several alloy makers not associated with steel plants to market such alloys do not appear to have been successful.

[1] Iron Age, vol. 98, p. 31, 1916.

## DOMESTIC MANGANESE DEPOSITS.

### ALABAMA.

Only two operators of manganese mines reported from Alabama for 1916. One mine in Etowah County shipped high-grade ore containing less than 1 per cent of iron.

### ARIZONA.

Six operators of manganese mines reported from Arizona for 1916, of which four made shipments. The Bunker Hill Mines Co. continued to mine ore from the Lucky Cuss, Oregon, and Escondido mines, at Tombstone, and shipped high-grade ore to makers both of dry batteries and of ferromanganese. The Phelps Dodge Corporation, the Shattuck Arizona Copper Co., and Thomas Higgins, shipped high-grade ore from Bisbee.

Many discoveries were reported in Cochise, Graham, Gila, Pinal, Yavapai, and Yuma counties, and most of them were explored during the first half of 1917.

### ARKANSAS.

Eighteen operators of manganese mines in Arkansas reported for 1916. The mines of five of them are in the western counties, Pike, Polk, and Montgomery, and the remainder, except one, are in the Batesville district. The shipments of high-grade ore from the Batesville district were 6,101 tons, which was slightly less than the maximum (6,708 tons) recorded in 1892.

For the first time in many years there were numerous attempts to exploit the deposits of western Arkansas, largely in Pike, Polk, and Montgomery counties. A summary of the features of the deposits, including a brief description of the methods of mining, appeared recently.[1]

A complete report on the deposits of a part of the western Arkansas district has recently been published.[2] The deposits were examined in connection with detailed stratigraphic and structural studies of the region, and the relations of the deposits are summarized as follows:[3]

> The manganese deposits of west-central Arkansas are found at intervals in a belt 4 to 12 miles wide extending west-southwestward from Pulaski County, at the center of the State, to Polk County, on the west border. Recent exploitation, begun in 1915, and still in progress, is confined almost entirely to the mountainous districts in Polk, Pike, and Montgomery counties. The deposits have been worked in a very small way and have yielded only a few hundred tons of marketed ore. The manganese ores consist of oxides, four of which, psilomelane, pyrolusite, manganite, and wad, have been identified; if others are present they probably occur in minute quantities. Although these minerals may be found separately, as a rule two or more are intimately mixed in the same deposit, and in some places they are associated with iron ores and manganiferous iron ores. The manganese ores are mainly confined to two stratigraphic horizons in the Arkansas novaculite. They occur as nodules, pockets, and short irregular veins from a fraction of an inch to 4 feet thick. Thicknesses of 4 feet, however, are rare, and those of a foot are not common. The ore bodies are scattered through the hard novaculite and can doubtless be found on every mountain where the Arkansas novaculite is exposed. The ores occupy bedding planes or joint cracks or form a cement in a novaculite breccia in which the rock fragments range from a fraction of an inch to more than a foot in diameter.

[1] Joslin, G. A., Manganese in west-central Arkansas; Min. and Sci. Press, vol. 113, pp. 947-948, 1916.
[2] Miser, H. D., Manganese deposits of the Caddo Gap and De Queen quadrangles, Ark.: U. S. Geol. Survey Bull. 660, pp. 59-122, 1917.
[3] Miser, H. D., personal communication.

## CALIFORNIA.

Of seventeen operators of manganese mines in California during 1916 five reported shipments from 10 mines. The shipments for the year, 6,054 tons, were the largest so far recorded from the State. Mines in Alameda County shipped more than half of the total, but other mines in Mendocino, Shasta, Sonoma, San Bernardino, and Butte contributed. Explorations were made also in other parts of the State.

At the end of the year three electric furnaces were in operation by the Noble Electric Steel Co., at Heroult. The plant is reported to produce ferromanganese, silico-manganese, and ferrochrome.

## COLORADO.

In 1916 high-grade manganese ore was shipped from Fremont, Saguache, and San Miguel counties, Colo. A small quantity of low-grade ore was shipped from Salida, Chaffee County. Twenty operators shipped low-grade ores from the Leadville district. The high price of manganese alloys has served to divert a large part of the Leadville shipments from use as flux to the manufacture of spiegeleisen. From 1910 to 1913, inclusive, the annual shipments ranged from 41,753 tons to 55,770 tons, and all was used as flux; in 1916, of 107,113 tons shipped, 90,850 tons were converted to spiegeleisen.

## GEORGIA.

Of nine operators in Georgia that reported in 1916 two companies operating in the Cartersville district shipped manganese ore from six mines. Deposits of manganiferous iron ore in Green and Taliaferro counties not previously recorded were explored during the year.[1] The first deposit is 8 miles northeast of Union Point and the second is 4 miles from Robinson.

## MICHIGAN.

Ore containing 16 per cent of manganese and 39.6 per cent of iron (dry basis) was mined during 1916 at the Bengal mine, Iron County, Mich.

## MINNESOTA.

Of nine operators on the Cuyuna range in Minnesota reporting for 1916, seven shipped ore that ranged from 5 to 20 per cent of manganese.

The geologic conditions on the Cuyuna range are described by Harder.[2] The manganiferous iron ores of the district are also described by Harder.[3] The known deposits of manganiferous iron ores are described with reference to their distribution, stratigraphic and structural associations, size, character, and grade of ore and origin. Eighty-three analyses show the range of composition of the ores.

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[1] Letter from George E. Harrison, Birmingham, Ala.

[2] Harder, E. C., Notes on the geology and iron ores of the Cuyuna district, Minn.: U. S. Geol. Survey Bull. 660, pp. 1–26, 1917.

[3] Harder, E. C., Manganiferous iron ores of the Cuyuna district, Minn.: Am. Inst. Min. Eng. Bull., September, 1917. pp. 1313–1344.

### MONTANA.

Although the oxidized parts of many metalliferous deposits of the Western States have been known to contain bodies of manganese ore formed by the oxidation of manganiferous carbonates, few have suspected that any of these deposits would be the source of large quantities of high-grade manganese ore. The Philipsburg district,[1] Granite County, Mont., produced large quantities of gold and silver ores from 1862 to 1893, when the low price of silver compelled most of the mines to close down. It was therefore a source of surprise when in 1916 rather large quantities of high-grade manganese ore were shipped from several mines. Early in 1917 eight mines were shipping and others were engaged in exploration. The ores are rather siliceous, but when mixed with foreign ores low in silica they may be smelted to 80 per cent ferromanganese. The average composition of 193 cars shipped from the district by one company in 1916 and 1917 was—manganese, 44.7 per cent; iron, 2.0 per cent; silica, 15.5 per cent; phosphorus, 0.023 per cent.

During 1916 deposits of high-grade ore were explored on the west side of Madison Valley, 7 miles southwest of Norris, Madison County.

### NEVADA.

Deposits of high-grade manganese ore were explored 15 miles southeast of Shafter, Elko County, Nev., and a small quantity was shipped. Other deposits were explored 8 miles east of East Ely, White Pine County.

The Prince Consolidated Mining Co. shipped from its mines near Pioche, 122,429 gross tons of ore, containing—manganese, 12.5 per cent; iron, 30 per cent; and silica, 12 per cent, to a lead smelter near Salt Lake City, Utah. The ore also contained—lead, 2.8 per cent; silver, 2.55 ounces per ton; and gold, trace. Large reserves of this class are reported.

### NEW MEXICO.

Three operators shipped ferruginous manganese ore from the Silver City district, N. Mex. The range in composition of 1,132 tons from the Silver Cross mine was—manganese, 11.7 to 16 per cent; iron, 34.2 to 38.7 per cent; silica, 12.8 to 17.10 per cent; and phosphorus 0.047 to 0.048 per cent. Similarly, the range in composition of 4,129 gross tons from the Legal Tender group was—manganese, 12.2 to 21 per cent; iron, 35.6 to 41.2 per cent; silica, 6.07 to 13.9 per cent; and phosphorus, 0.013 to 0.020 per cent. A large part of the ore from this district was mixed with manganiferous ores from the Leadville district, Colo., and smelted to 32 per cent spiegeleisen at Pueblo.

Deposits of manganese ore were explored 2 miles north of Fierro, Grant County.[2]

### OKLAHOMA.

A car of manganese ore was collected in the spring of 1916 near Pine Mountain Springs, McCurtain County, Okla., and shipped from Hatton, Ark.[3]

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[1] Emmons, W. H., and Calkins, F. C., Geology and ore deposits of the Philipsburg quadrangle, Mont.: U. S. Geol. Survey Prof. Paper 78, 271 pp., 1913.

[2] Letter from M. N. Dowell, Fierro, N. Mex.

[3] Oral communication from H. D. Miser, Washington, D. C.

### OREGON.

The Oregon Manganese Co., of Portland, explored deposits 6 miles east of Wolf Creek, Josephine County, Oreg. Other deposits are reported in the vicinity.[1]

Several deposits of high-grade ore were explored 2 to 4 miles northeast of Pleasant Valley, Baker County.

### SOUTH CAROLINA.

The manganese deposits near McCormick, Abbeville County, S. C., are briefly described by R. W. Petre.[2] The ore is found in three lenticular deposits, the Dora, Belle, and New York, which are from 6 to 30 feet wide and from 700 to 900 feet long. The latest shipments of about 500 tons in 1914 contained—manganese, 43 per cent; iron, 2.10 per cent; silica, 5 per cent; and phosphorus, 0.16 per cent. The deepest explorations extend 30 feet below the surface. The mines were idle in 1915 and 1916.

### TENNESSEE.

Deposits of high-grade manganese ore in Bradley County, Tenn., 8 miles south of Cleveland and 1 mile east of Weatherby, a siding on the Southern Railway, are described by Joel H. Watkins.[3] The average composition of the ore is reported to be—manganese, 54.2 to 56.1 per cent; iron, 2.21 to 3.3 per cent; silica, 0.5 to 0.7 per cent; phosphorus, 0.1 to 0.14 per cent. The manganese oxides replace the Holston marble in the zone of its contact with the Tellico sandstone. Thus far only sporadic masses of manganese ore have been found, but it is thought that they may be found over a large area.

### TEXAS.

High-grade manganese ore was shipped from the Spiller mine, 32 miles west of Llano, Llano County, Tex., by the Wakefield Iron & Coal Land Improvement Co., of Minneapolis, Minn.

### UTAH.

The increase in number of shippers of manganese ore in Utah during 1916 was due largely to activity in the Little Grand district, Grand County. The shipments of high-grade ore containing less than 2 per cent iron from this county were second only to those from the Tombstone district, Ariz. Small shipments were also reported from mines near Marysvale, Sevier County.

### VIRGINIA.

The number of shippers of high-grade manganese ore in Virginia in 1916 was twice that of 1915 and the shipments were nearly three times as large. A large part of the increase in shipments came from the Crimora mine, Augusta County, where a large new mill was completed early in the summer.[4]

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[1] Letter from S. S. Wolfson, Grants Pass, Oreg.
[2] Manganese in South Carolina: Eng. and Min. Jour., vol. 101, p. 1019, 1916.
[3] Manganese in Tennessee: Eng. and Min. Jour., vol. 102, p. 545, 1916.
[4] Mining of manganese ore in Virginia: Iron Age, vol. 97, p. 776, 1916; Schubert, E. A., The production of Virginian manganese: Iron Trade Rev., vol. 60, p. 1032, 1917; Manganese production in Virginia: Mfrs. Record, vol. 72, p. 52, 1917.

The Kennedy mine near Stuart's Draft, was prospected by drilling in 1916 and preparations were made to wash ore for shipment.

The manganiferous iron deposits at Iron Mountain, 5 miles east of Pkin Siding, between Lofton and Vesuvius, Augusta County, were explored and equipment was installed with the view to operation.

In Campbell County the Consolidated Manganese Corporation operated the Piedmont mine 2 miles south of Sixmile Bridge and shipped high-grade ore.

In Rockbridge County the Rockbridge Manganese & Iron Co. operated the Midvale mine and shipped both high and low grade ore.

The United States Manganese Corporation explored new deposits 3,000 feet northeast of the Niesswaner shaft 1 mile south of Elkton, Rockingham County, and shipped high-grade ore.

In Shenandoah County the old Powells Fort mine was operated by H. P. Binswanger, of New York.

In Smythe County deposits of manganese ore were worked near Sugar Grove, and deposits of manganiferous iron ore near Attoway and Amburg were sources of shipments.

### WASHINGTON.

Although there were explorations in Washington on manganese deposits near Humptulips, Grays Harbor County, and on others near Omak, Okanogan County, the only shipments for the year were derived from the deposits on the south fork of Skokomish River, Mason County. These ores were shipped to Tacoma, where they were reduced to ferromanganese in an electric furnace operated by the Bilrowe Alloys Co.

## FOREIGN MANGANESE DEPOSITS.

### AUSTRALIA.

The Australian Manganese Co.[1] explored and shipped high-grade manganese ore from a deposit near Woocalla, on the East-Wes Railway, 76 miles from Port Augusta.

### AUSTRIA.

H. K. Scott[2] describes the manganese deposits of the Dorna Vatra district, Bukowina, Austria. The article contains descriptions under the following headings: Situation, historical, mining laws, geology and occurrence of the ores, estimate of ore available, method of mining, treatment, cost of operation and selling price. The ores that are mined are the weathered parts of lenses of rhodonite and rhodochrosite, inclosed in mica schist.

### BRAZIL.

Harder[3] has described the manganese deposits of Brazil.

Singewald and Miller[4] have described the geologic features of the deposits worked at the Piquery and Morro da Mina mines, Lafayette

[1] Letter from Australian Manganese Co., Broken Hill, New South Wales, Mar. 8, 1916.
[2] Manganese ores of the Bukowina: Iron and Steel Inst. Jour., vol. 94, pp. 288-355, 1916.
[3] Harder, E. C., Manganese ores of Russia, India, Brazil, and Chile: Am. Inst. Min. Eng. Trans., vol. 56, pp. 31-68, 1916.
[4] Singewald, J. T., jr., and Miller, B. L., Manganese ores of the Lafayette district, Minas Geraes, Brazil: Am. Inst. Min. Eng. Trans., vol. 56, pp. 7-30, 1916.

district. The Piquery mine has been exhausted, but the Morro da Mina mine is estimated to contain a reserve of 10,000,000 tons, although it has already yielded 1,000,000 tons. The ore that is shipped from the Morro da Mina mine is largely psilomelane, with some manganite and pyrolusite, and has an average composition of manganese, 50.47 per cent; oxides of iron and alumina, 8.75 per cent; silica, 1.76 per cent; phosphorus, 0.069 per cent; and water, 2.50 per cent. This ore has been formed by the weathering near the surface of a peculiar rock which contains manganese carbonate, spessartite, rhodonite, and tephroite. Singewald and Miller consider that this rock is "the product of dynamometamorphism of manganese sediments deposited in the form of manganese carbonate with varying but considerable quantities of silica and varying but smaller quantities of alumina." This view differs from that first announced by Derby [1] and apparently adhered to by Harder [2] that the original rock was largely spessartite and of igneous origin. Weathering has formed large masses of oxides that persist 130 meters below the outcrop.

Garrison [3] describes briefly the important resources of Brazil, principally iron, manganese, gold, and diamonds.

The exports of manganese ore from Brazil are reported [4] as follows: 1914, 183,330 metric tons; 1915, 288,671 metric tons; 1916, 503,130 metric tons.

## CANADA.

Small deposits of manganese ore have recently been discovered south of Maple Creek, southern Alberta.[5]

The manganese deposits near Conception and Trinity bays, Newfoundland, are described by N. C. Dale.[6] Many analyses of the ores have been recalculated to show their constitution. The range in composition is—manganese carbonate, 11 to 45 per cent; manganese dioxide, 2 to 34 per cent; calcium carbonate, 4 to 58 per cent; magnesium carbonate, 3 to 10 per cent; and small percentages of silica, iron oxide, and barium sulphate. The ores form beds that are interbedded with siliceous sediments of Cambrian age.

## CHILE.

Harder [7] describes the manganese deposits of the Carrizal, Las Cañas, La Liga, Arrayan, and Corral Quemada districts, Chile, from examinations made in 1914. The ores of the Carrizal district are bauxite, psilomelane, and other oxides, which form beds from less than a foot to 4 or 5 feet thick, interbeded with gray chert, gray limestone, and gray shales of Mesozoic age. In the other districts the ores are beds of compact, soft pyrolusite, which range from thin seams to beds 4½ feet thick and are interbedded with red and pink sandstone, shale, and limestone and with flows of trachyte.

[1] Derby, O. A., On the manganese ore deposits of the Quelus (Lafayette) district, Minas Geraes, Brazil: Am. Jour. Sci., 4th Ser., vol. 12, pp. 18–32, 1900.
[2] Harder, E. C., op. cit., p. 790.
[3] Garrison, F. L., The mining industry of Brazil: Min. and Sci. Press, vol. 114, pp. 329–333, 1917.
[4] Jornal do Commercio, Rio Janeiro, Feb. 1, 1917.
[5] Personal communication from J. G. Ross, Montreal, Canada.
[6] The Cambrian manganese deposits of Conception and Trinity bays, Newfoundland: Am. Philos. Soc. Proc., vol. 54, pp. 371–456, 1915.
[7] Harder, E. C., op. cit., pp. 62–68.

The largest annual exports from all districts, 50,871 tons, were made in 1892, and the total exports from 1885 to 1905 are 549,716 tons. No ore has been shipped since 1905.

### COSTA RICA.

Consul B. F. Chase, of San Jose,[1] reports that deposits of manganese ore are being exploited near Playa Real, Guanacaste, Costa Rica. A company is installing docks and other equipment for loading ocean steamers at a point 2 miles south of Brazilito and north of the Pacific port of Punta Arenas. The ore is of high grade and is reported to contain 55 per cent of manganese or 80 to 83 per cent of manganese dioxide. Imports of manganese ore from Costa Rica in 1916 were 1,244 tons.

### CUBA.

Consul P. M. Griffith reports [2] that two companies, Aguilera & Co. and the Cauto Mining Co., shipped manganese ore from three mines in 1916. The former company shipped from the Ponupo and Cristo mines and the latter from the mines near San Nicolas, Oriente.

In addition it is reported that small shipments were made by J. Cendoya & Co. from La Gloria mine, near Dos Caminos, Oriente.

Deposits of manganese ore near Cabagan, Santa Clara, 40 miles west of Trinidad, were exploited by the Trinidad Manganese Co., of Habana, during 1916. The deposits are 2 miles from the coast, but a small consignment was shipped to the United States early in 1917.

### MEXICO.

Deposits of high-grade manganese ore have been reported [3] to exist near Candela, in eastern Coahuila.

### NEW ZEALAND.

A. A. Winslow, consul general, Auckland, New Zealand, has submittted a description by the owner [4] of a deposit of high-grade manganese ore 3 miles from Otau, 35 miles south of Auckland. It is estimated that 16,000 to 18,000 tons of ore are exposed.

### PANAMA.

Consul Julius D. Dreher [5] reports the shipment of 300 tons of manganese ore from a mine at Madinga, Gulf of San Blas, Panama. The mine appears to be 20 or more miles east of those near Nombre de Dios that have been the scene of much exploration.

### PHILIPPINE ISLANDS.

According to advices [6] received from the Philippines by the Bureau of Insular Affairs, 3,000 metric tons of manganese ore were produced during 1916. The market for this product is not known, but may be Japan.

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[1] Daily Cons. and Trade Reports, Jan. 24, 1917.
[2] Idem, Oct. 21, 1916.
[3] Personal letter from R. C. Bateman, Washington, D. C.
[4] Cheal, P. E., Remuera, Auckland, New Zealand.
[5] Daily Cons. and Trade Reports, Mar. 1, 1916.
[6] Cablegram from governor general.

### PORTO RICO.

The presence of high-grade manganese ore 6 miles from Juana Diaz, which is 10 miles east of Ponce, is reported by Manuel V. Domenech,[1] Commissioner of the Interior, Porto Rico.

### RUSSIA.

Harder[2] presents descriptions of the manganese deposits of the Tchiaturi and Nicopol districts, Russia, based on a compilation of available information. The location, extent, geologic relations, and cost of mining are given.

Scott[3] presents data concerning reserves of ore in both the Tchiaturi and Nicopol districts. He estimates the "quantity of ore available for extraction" from the Tchiaturi deposits to be 22,125,000 tons.

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[1] Letter, July 5, 1917.
[2] Harder, E. C., Manganese ore of Russia, India, Brazil, and Chile: Am. Inst. Min. Eng. Trans., vol. 56, pp. 31–68, 1916.
[3] Scott, H. K., Am. Inst. Min. Eng. Trans., vol. 56, pp. 68–74, 1916.

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# QUICKSILVER.

By H. D. McCaskey.

## INTRODUCTION.

This report, for the year 1916, has been unduly delayed owing to the largely increased administrative work of the writer incident to the war demands upon the division of the Geological Survey under his charge. For this reason also the writer has been unable to continue the Survey work on quicksilver begun 10 years ago. He takes this opportunity to express to all who are engaged in that industry his appreciation not only for their cordial cooperation with the efforts of the Survey to record their progress but also for the many courtesies extended to him in the performance of his work in field and office.

The quicksilver industry is fortunate in having as its future historian Frederick Leslie Ransome, the geologist in charge of investigations of metalliferous deposits of the United States Geological Survey—a scientist equipped by training, experience, and inclination to be of greatest service both to the industry and to the Government.

## CONDITION OF THE INDUSTRY.

The domestic quicksilver industry continued active throughout 1916, owing principally to conditions brought about by the war. These were, briefly, an increased demand for use in munitions, a market largely restricted to domestic output because of foreign embargoes on export, a consequent rise in prices, highly profitable current operations, and good prospects for future profits.

In February and March attempts to profiteer by speculators outside the industry, according to reports, brought the price to over $300 a flask, but the effort proved abortive when supplies to complete domestic contracts for the British Government were obtained from abroad. The market then became normal with strong demand at profitable but reasonable prices.

The mines and their reduction works were generally active throughout the year, and the outlook justified reopening of old properties and search for and development of new prospects. At some mines the richest ore was taken out to provide capital for further operations, and although this added materially to the output

in time of need and brought profitable returns at the moment, the effect was to lower the average grade of ore available for future treatment.

Although the industry enjoyed high prices and continuous demand, reserves have been heavily drawn upon, new ore bodies have not in the main been discovered to replace depleted resources, costs of operation have steadily climbed, and profits on the whole have not been equal to expectation. The domestic mines may continue to count upon a fair demand at favorable prices, but they must follow the best engineering practice and sound financial guidance to keep gross income above costs. The same war conditions that brought financial rewards also brought abnormal difficulties to be overcome.

## USES OF QUICKSILVER.

Quicksilver is used mainly in making fulminate as a detonator for explosives, drugs (calomel, corrosive sublimate, mercurial ointment, etc.), pigment (vermilion), electrical appliances (primary batteries, rectifiers, mercury vapor lamps, etc.), physical apparatus (thermometers and barometers), boiler compounds, and phthalic acid, and also in amalgamation of precious metals, especially gold, in their recovery from gravels and free-milling ores. Its former principal uses in milling gold and silver and in silvering mirrors have largely declined, but a considerable demand has developed in recent years in making antifouling paint for ships' bottoms, and projected new uses, such as the conservation of heat in the generation of steam, give promise of development.

In recent months the Survey has made detailed investigations as to the domestic consumption of quicksilver, and the results will be available for the 1917 report.

## PRODUCTION.

### NUMBER OF MINES, OUTPUT OF METAL, AND VALUE.

There were 66 producers of quicksilver in 1916, including all small prospects, against 39 in 1915, 30 in 1914, and 24 in 1913. There are always some mines or prospects (under development chiefly) that produce ore but no metal, and usually a few old mines and furnace dumps that produce metal from clean-ups but no ore from mine operations. In the enumeration producers of metal only are included. Forty-four of the producers were in California in 1916 (an increase of 12 over 1915 and of 24 over 1914), 10 were in Nevada (an increase of 6 over 1915 and of 3 over 1914), 5 were in Texas (an increase of 4), 5 in Oregon (an increase of 4), and 1 small property produced in Arizona and another in Washington. Of the California producers 26 supplied less than 100 flasks each, only 7 had an output of over 500 flasks, and only 4 of over 1,000 flasks; in Texas 2 produced more than 1,000 flasks, and the remaining 3 less than 500; in Nevada 5 produced less than 100 flasks and only 1 more than 500

flasks; and in Oregon 4 of the 5 producers made only a nominal output.

Confidential returns to the Geological Survey from every producing district gave the output of quicksilver in the United States in 1916 as 29,932 flasks of 75 pounds each, against 21,033 flasks in 1915. With high prices and in the absence of excessive burdens the production should be maintained at 30,000 to 35,000 flasks, at least until 1920.

At the average price of $125.89 per flask quoted at San Francisco for domestic quicksilver, the output for 1916 was valued at $3,768,139—a value exceeded only in 1875 (when it was $4,228,538) in all the history of the domestic industry from 1850 to 1916, inclusive. In 1915 the value, based on the San Francisco quoted price of $85.80, was $1,804,631, against $811,680 in 1914. Compared with 1915 the production for 1916 showed an increase of 42 per cent in quantity and of 109 per cent in value.

The production of California increased 47 per cent in quantity and 116 per cent in value in 1916, against 26 and 112 per cent in 1915. The output of Nevada decreased 6 per cent in quantity and increased 39 per cent in value, against increases of 11 and 105 per cent in 1915; and the output of the other States, Arizona, Oregon, Texas, and Washington combined, increased 51 per cent in quantity and 122 per cent in value over the output of Arizona, Texas, and Oregon combined in 1915.

*Quicksilver produced in the United States, 1914–1916.*

| State. | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|
| | Quantity (flasks). | Value. | Quantity (flasks). | Value. | Quantity (flasks). | Value. |
| Arizona | 3,156 | $154,801 | 4,423 | $379,493 | 383 | $48,216 |
| California | 11,303 | 554,414 | 14,283 | 1,225,481 | 21,045 | 2,649,355 |
| Nevada | 2,089 | 102,465 | 2,327 | 199,657 | 2,198 | 276,706 |
| Oregon | (a) | (a) | (b) | (b) | (b) | (b) |
| Texas | (b) | (b) | (b) | (b) | 6,306 | 793,862 |
| Washington | (a) | (a) | (c) | (c) | (b) | (b) |
| | 16,548 | 811,680 | 21,033 | 1,804,631 | 29,932 | 3,768,139 |

a No output in 1914. b Included with Arizona. c No output in 1915.

## ORE TREATED AND RECOVERY OF METAL.

According to reports from producers 249,732 short tons of ore and other furnace material was treated in 1916, against 158,817 tons in 1915, the large increase being in part only a measure of the development of new bodies and exploitation of old ones to take advantage of high prices.

The average recovery in 1916 was 0.45 per cent of metal in ore treated, or 9.0 pounds of quicksilver per ton, against 0.497 per cent in 1915, or 9.9 pounds per ton, and 0.505 per cent in 1914, or 10.1 pounds per ton.

In California 205,072 short tons were treated, averaging 0.38 per cent, or 7.7 pounds per ton, against 129,521 tons in 1915, averaging

0.41 per cent, or 8.3 pounds per ton. In Nevada 12,911 tons treated averaged 0.64 per cent, or 12.8 pounds per ton, against 21,975 tons averaging 0.40 per cent, or 7.9 pounds per ton, in 1915. In Texas 25,945 tons were treated in 1916, averaging 0.91 per cent, or 18.2 pounds per ton.

*Quicksilver ore treated and average recoveries, 1915 and 1916.*

| State. | 1915 | | | 1916 | | |
|---|---|---|---|---|---|---|
| | Ore treated (short tons). | Metal recovered per ton (pounds). | Percentage of ore recovered as metal. | Ore treated (short tons). | Metal recovered per ton (pounds). | Percentage of ore recovered as metal. |
| Arizona | 7,321 | 45.3 | 2.27 | 5,804 | 4.9 | 0.25 |
| California | 129,521 | 8.3 | .41 | 205,072 | 7.7 | .38 |
| Nevada | 21,975 | 7.9 | .40 | 12,911 | 12.8 | .64 |
| Oregon | (a) | (a) | (a) | (a) | (a) | (a) |
| Texas | (a) | (a) | (a) | 25,945 | 18.2 | .91 |
| Washington | (b) | (b) | (b) | (a) | (a) | (a) |
| | 158,817 | 9.9 | .497 | 249,732 | 9.0 | .45 |

a Included with Arizona. b Washington had no output in 1915.

In the following table the relative importance of shaft and retort furnaces is clearly brought out. A total of only 3,960 short tons was treated in retorts, which yielded 2,250 flasks of quicksilver, or an average of 2.13 per cent of the ore charged, against 245,772 tons treated in furnaces, with a production of 27,682 flasks, or 0.42 per cent of the quantity treated.

*Quicksilver ore treated in retorts and in furnaces in 1916.*

| State. | Ore treated (short tons). | | Quicksilver recovered (flasks). | | Percentage of metal recovered per ton of ore treated. | |
|---|---|---|---|---|---|---|
| | Retorts. | Furnaces. | Retorts. | Furnaces. | Retorts. | Furnaces. |
| Arizona | 58 | 5,746 | 97 | 286 | 6.27 | 0.19 |
| California | 2,333 | 202,739 | 1,548 | 19,497 | 2.49 | .36 |
| Nevada | 1,569 | 11,342 | 605 | 1,593 | 1.45 | .53 |
| Oregon | (a) | (a) | (a) | (a) | (a) | (a) |
| Texas | ..... | 25,945 | ..... | 6,306 | ..... | .91 |
| Washington | (a) | (a) | (a) | (a) | (a) | (a) |
| | 3,960 | 245,772 | 2,250 | 27,682 | 2.13 | .42 |

a Combined with Arizona.

## METHODS OF REDUCTION.

In preceding reports some notes and references have been given on methods of reducing quicksilver ores to metal. In the 1917 report the subject will again be reviewed by F. L. Ransome.

The Bureau of Mines through its experiment station at Berkeley, Cal., is now engaged upon an investigation of the metallurgy of quicksilver. Particular attention has been given to the direct furnace treatment of ores in the

Scott furnace, which is the type of furnace usually employed in this country. A study of furnace operations at several plants has confirmed the belief that when properly operated a practically complete elimination of quicksilver from the ore can be accomplished in the Scott furnace. In some cases, however, sufficient attention does not appear to have been given to regulation of furnace firing, and it is believed that a more extended use of pyrometers and greater care in regulating combustion with particular reference to the air admitted to the furnace will result in both a saving of fuel and a reduction in the quicksilver lost in the burnt ore leaving the furnace.

A series of direct determination of quicksilver losses occurring in the fume leaving the stack made at two quicksilver plants in California led to the conclusion that under the usual method of Scott furnace and condenser operation this loss is very small, being less than 1 per cent of the quicksilver entering the furnace.

Considerable attention has also been given to the study of condensing operations, and some experiments for the purpose of determining the best method of condensation are now under way.

A critical study has been made of methods of assaying quicksilver ores with particular reference to ores high in sulphur or bituminous matter, and by a combination and improvement of old methods an analytical procedure has been devised which is both rapid and accurate.[1]

## DEPOSITS, ORES, AND GANGUES.

In the Survey report on quicksilver for 1911 the writer gave a summary of deposits, ores, and gangues, mainly for the benefit of those not needing great detail—miners, prospectors, and others—to whom the literature on the subject may not be readily accessible. The information has apparently served its purpose, and a more thorough discussion of the subject has been undertaken by F. L. Ransome for the report for 1917. A few copies of the report for 1911 are still available for distribution by the Survey.

## RESOURCES, OCCURRENCES, AND DEVELOPMENTS, BY STATES.

### ALASKA.

Data on the small quantity of quicksilver reported as produced and consumed in Alaska are not yet available, but the occurrence of cinnabar ore in lode and placer gravels has been known in the Territory for many years. Reference has been made in previous reports to the localities.

According to Brooks[2] there was some mining of quicksilver ores in the lower Kuskokwim, and some work was done on three or four prospects, besides continuation of development work at the Parks mine. In the Tolovana district, according to Mertie,[3] the concentrates taken with the gold on Lillian Creek carry cinnabar, and this mineral is also found in Olive and Ester creeks and is reported from the head of Ruth Creek. According to Mertie,[4] also, six silver-lead lodes have been reported on Seward Peninsula, one of which, on Fish River, about 5 or 6 miles above Niukluk River, in the Council

[1] Letter from Bureau of Mines, Dec. 6, 1917.
[2] Brooks, A. H., and others, Mineral resources of Alaska, 1916: U. S. Geol. Survey Bull. 662, p. 60, 1917.
[3] Idem, p. 270.
[4] Idem, p. 446.

district, is said to have been worked sporadically. Cinnabar is present on this property, and it is reported that a number of flasks of mercury have been produced annually here for several years past.

## ARIZONA.

There was again a small output of quicksilver from Arizona in 1916. The total production to date has been of minor importance, as the development work remains largely in the prospect stage. Occurrences of cinnabar in the State have been mentioned in previous reports.

In the Mazatzal Range, in Maricopa County, a nominal production was made by Christopher Martin in 1916, and assessment and development work only was done on the properties of the Sunflower Cinnabar Mining Co. In the Phoenix Mountains, a few miles from Phoenix, discoveries of cinnabar in metamorphic schists of pre-Cambrian age were made by L. L. Brunson, J. A. Porterie, Henry Porterie, and Samuel Hughes, and claims were staked and preliminary development work was done. The prospects are described by Schrader,[1] who made a brief field examination early in 1917. According to Schrader the Mercury, Rico, and Seal Rock properties have workable ore averaging 3 per cent of metal and may have considerable extent of favorable ground for prospecting or development. From geographic location and similarity of geologic field conditions Schrader suggests an area of the McDowell Mountains, between the Phoenix and Mazatzal mountains, as worthy of prospecting for quicksilver deposits. It is apparent that only thorough development, systematic mining, and more modern metallurgic methods will determine whether a considerable output of quicksilver may be hoped for from Maricopa County, and capital in sufficient quantity must be available for expenditure under competent engineering supervision.

## CALIFORNIA.

The quicksilver industry remained generally active in California in 1916. High prices continued, and there was considerable prospecting, development, and furnace repair and equipment.

The production of quicksilver in California in 1916 was 21,045 flasks, valued at $2,649,355, of which 19,497 flasks were produced from shaft furnaces and 1,548 flasks from retorts. The output in 1915 was 14,283 flasks, valued at $1,225,481. The production in 1916 was the largest in quantity since 1905, the greatest in value since 1877, and the highest in average price per flask ever recorded. In 1916 California furnished 70 per cent of the total domestic production, against 68 per cent in 1915.

In the following table are given the best available data for the production of quicksilver in California from 1850, the year of earliest yield, to the end of 1916. The flask is taken at 76½ pounds net of quicksilver until June, 1904, and 75 pounds since that date.

[1] Schrader, F. C., Quicksilver deposits of the Phoenix Mountains, Ariz.: U. S. Geol. Survey Bull. 690, pp. 95–109, 1918.

*Quicksilver produced in California, 1850–1916.*

| Year. | Quantity (flasks). | Price per flask. | Value. | Year. | Quantity (flasks). | Price per flask. | Value. |
|---|---|---|---|---|---|---|---|
| 1850 | 7,723 | $99.45 | $768,052 | 1885 | 32,073 | $30.75 | $986,245 |
| 1851 | 27,779 | 66.93 | 1,859,248 | 1886 | 29,981 | 35.50 | 1,064,325 |
| 1852 | 20,000 | 58.33 | 1,166,600 | 1887 | 33,760 | 42.375 | 1,430,580 |
| 1853 | 22,284 | 55.45 | 1,235,648 | 1888 | 33,250 | 42.50 | 1,370,625 |
| 1854 | 30,004 | 55.45 | 1,663,722 | 1889 | 26,464 | 45.00 | 1,190,880 |
| 1855 | 33,000 | 53.55 | 1,767,150 | 1890 | 22,926 | 52.50 | 1,203,615 |
| 1856 | 30,000 | 51.65 | 1,549,500 | 1891 | 22,904 | 45.25 | 1,036,406 |
| 1857 | 28,204 | 48.73 | 1,374,381 | 1892 | 27,993 | 40.71 | 1,139,595 |
| 1858 | 31,000 | 47.83 | 1,482,730 | 1893 | 30,164 | 36.75 | 1,108,527 |
| 1859 | 13,000 | 63.13 | 820,690 | 1894 | 30,416 | 30.70 | 933,771 |
| 1860 | 10,000 | 53.55 | 535,500 | 1895 | 36,067 | 37.04 | 1,335,922 |
| 1861 | 35,000 | 42.05 | 1,471,750 | 1896 | 30,765 | 34.96 | 1,075,544 |
| 1862 | 42,000 | 36.35 | 1,526,700 | 1897 | 26,691 | 37.28 | 995,040 |
| 1863 | 40,531 | 42.08 | 1,705,544 | 1898 | 31,992 | 38.23 | 1,188,647 |
| 1864 | 47,489 | 45.90 | 2,179,745 | 1899 | 29,454 | 47.70 | 1,404,956 |
| 1865 | 53,000 | 45.90 | 2,432,700 | 1900 | 26,317 | 44.94 | 1,182,686 |
| 1866 | 46,550 | 53.13 | 2,473,292 | 1901 | 26,720 | 48.46 | 1,294,851 |
| 1867 | 47,000 | 45.90 | 2,157,300 | 1902 | 28,972 | 43.20 | 1,251,590 |
| 1868 | 47,728 | 45.90 | 2,190,715 | 1903 | 30,526 | 45.29 | 1,382,523 |
| 1869 | 33,811 | 45.90 | 1,551,925 | 1904 | 29,217 | 43.50 | 1,270,940 |
| 1870 | 30,077 | 57.38 | 1,725,818 | 1905 | 24,635 | 36.22 | 892,280 |
| 1871 | 31,686 | 63.10 | 1,999,387 | 1906 | 20,310 | 39.50 | 802,245 |
| 1872 | 31,621 | 65.93 | 2,084,773 | 1907 | 17,431 | 39.60 | 690,268 |
| 1873 | 27,642 | 80.33 | 2,220,482 | 1908 | 16,984 | 44.17 | 750,183 |
| 1874 | 27,756 | 105.18 | 2,919,376 | 1909 | 16,078 | 45.45 | 730,745 |
| 1875 | 50,250 | 84.15 | 4,228,538 | 1910 | 17,211 | 46.51 | 800,484 |
| 1876 | 72,716 | 44.00 | 3,199,504 | 1911 | 18,860 | 46.01 | 867,749 |
| 1877 | 79,395 | 37.30 | 2,961,434 | 1912 | 20,524 | 42.05 | 863,034 |
| 1878 | 63,880 | 32.90 | 2,101,652 | 1913 | 15,591 | 40.23 | 627,228 |
| 1879 | 73,684 | 29.85 | 2,199,467 | 1914 | 11,303 | 49.05 | 554,414 |
| 1880 | 59,926 | 31.00 | 1,857,706 | 1915 | 14,283 | 85.80 | 1,225,481 |
| 1881 | 60,851 | 29.83 | 1,815,185 | 1916 | 21,045 | 125.89 | 2,649,355 |
| 1882 | 52,682 | 28.23 | 1,487,213 | | | | |
| 1883 | 46,725 | 28.75 | 1,343,344 | | 2,186,914 | ..... | 100,330,762 |
| 1884 | 31,913 | 30.50 | 973,347 | | | | |

As usual, San Benito County, in which is the New Idria mine, the largest producer of the Western Hemisphere, led in production. It was followed in order by Santa Clara County (with the largest total output to date), in which are the New Almaden and New Guadalupe mines, and San Luis Obispo County, with many properties and one large producer—the Oceanic.

There were 44 mines and prospects from which production was reported in California in 1916, against 32 in 1915 and 20 in 1914. Altogether 205,072 tons of new and old ore, concentrates, and furnace material were treated in 1916, against 129,521 tons in 1915. Of the ore treated the shaft furnaces received 202,739 tons in 1916, against 127,251 tons in 1915, and the retorts 2,333 tons, against 2,270 tons in 1915.

*Quicksilver produced in California, 1916, by counties.*

| County. | Quantity (flasks). | Value. |
|---|---|---|
| Lake | 1,107 | $139,360 |
| Napa | 583 | 73,394 |
| San Benito | 11,131 | 1,401,282 |
| San Luis Obispo | 1,556 | 195,885 |
| Santa Clara | 4,126 | 519,422 |
| Sonoma | 1,128 | 142,004 |
| Other counties[a] | 1,414 | 178,008 |
| | 21,045 | 2,649,355 |

[a] Includes Colusa, Fresno, Kern, Kings, Monterey, Santa Barbara, Solano, Stanislaus, and Trinity.

*Colusa County.*—The Wilbur Hill mine, an old claim being worked over, produced a small quantity of quicksilver from retorting of concentrates in 1916. The equipment was small, and concentrating was limited to the winter owing to shortage of water supply. At the New Elgin mine a small quantity of surface ore was concentrated and treated in retorts for experimental purposes and the mine was developed in the lower levels.

*Fresno County.*—The Mercy mine was still in litigation, but a small output of metal was cleaned up from furnace soot in 1916.

*Kern County.*—The Cuddeback Cinnabar mine made a small production from retorts from operations begun in December.

*Kings County.*—The Kings mine produced a considerable quantity of ore in 1916, which was treated in a 10-ton Scott furnace.

*Lake County.*—The Great Western mine was prepared for production by the installation of a new plant equipped for concentration, and the Wall Street mine continued its steady though small output from the retorting of high-grade ore and concentrates. A new 6-ton furnace was also installed at the Wall Street but like most new furnaces did not produce when first placed in operation. The Helen mine was further developed and again produced a large quantity of ore, most of which was treated in the 50-ton Scott furnace, making a considerable output. The Big Injun, an old property, was equipped with two D-retorts and produced from ore taken out in development work. The Chicago mine made a nominal output in the course of a small amount of assessment work done. At the Sulphur Banks, another old property, some quicksilver was recovered in the wrecking of old furnaces and condensers, which yielded the metal from the bricks and mortar treated in a D-retort.

*Mendocino County.*—The old Wise quicksilver mine, now the Occident, was operated as early as 1875 by a Mr. Wise, and the ore was treated in two D-retorts with a considerable output. The claim was later "jumped" and patented in 1883 by W. E. Gillespie, leased by him to others, and in 1901 developed and brought to a producing stage. The output was valued at $30,000 by 1906,[1] when the earthquake stopped operations. In 1916 W. H. M. Smallman undertook to reopen the property but, finding the old workings badly caved, was forced to abandon them and was exploring new ground with the intention of operating retorts on ore developed. There was no production of quicksilver from this mine in 1916.

*Monterey County.*—The Patriquin mine was operated and made a considerable output from ore treated in the 24-pipe Johnson-McKay retort plant.

*Napa County.*—A small production was made from a clean-up at the Knoxville mine and a larger output from concentrating the old waste dumps of the Oat Hill mine, but operations at the Oat Hill were limited to the first seven months of the year, owing to shortage of water. At the Twin Peaks prospecting and the retorting of some ore found resulted in a nominal output. The old La Joya mine was reopened in 1916 and made a small production from its Fitzgerald furnace, and at the White Elephant some development and experimental retorting was reported.

[1] Letter from W. H. M. Smallman.

The Manhattan mine was not operated, but a small quantity of quicksilver was produced from a clean-up around the old plant. The James Creek operations consisted in making 35 to 40 per cent concentrates by the use of hand rockers on gravel derived from the old Oat Hill dumps; the concentrates were retorted in 4-inch iron pipes and yielded a small production of metal. At the Vallejo property a few flasks were obtained from the retorts in 1916.

*San Benito County.*—The Alpine mine was equipped with a 20-ton Scott furnace from which first production was begun in June. A small output was reported from the Fourth of July property and also from the Archer, Santo Domingo, Florence-Mac, and I X L properties. The Florence-Mac was equipped with a Huntington mill and concentrating table but was operated only part of the year. Some development was done on the Wonder property, and production was made from a 6-pipe retort.

The New Idria mine continued to be the most important quicksilver producer in America. The property was equipped with four furnaces and produced 10,828 flasks, according to the published annual report, against 6,250 flasks in 1915. The property was operated with a net profit of $419,235.50, of which $400,000 was paid in four dividends declared. Total expenses of operation, including installation of new mill and aerial tramway and development work, were $514,359.01, and gross receipts from all operations were $933,594.51.

The ore worked during the year at the New Idria came from the New Idria mine upper levels and dumps, also from the San Carlos mine upper levels and dumps. The aerial tramway (about 1 mile long) from San Carlos Mountain to the Idria furnaces was completed and was most successful in working 24 hours to the day transporting ore at small cost by gravity. The new crushing mill and concentrating plant also worked satisfactorily in handling lower-grade ores than were formerly possible. Changes in the concentration and smelting plants were under consideration, looking to further decrease in cost, larger percentage of extraction, and increased production, and also to a new aerial tram from the Idria mine to the furnaces. During the year an assayer and furnace expert were employed with important results toward future solution of reduction and fuel problems. A new 1,000-barrel fuel-oil tank was added to the equipment, and large storage bins for ore were under consideration to insure continuous operation of the furnaces with a minimum labor supply and during all contingencies of mine operations. Also in view were an electric power line to the mines and a power drag to deliver the entire dumps from the top of the mountain to the No. 5 level, at which a sorting and screening plant would be employed and from which an aerial tram would convey the ore to the furnaces at the bottom or mouth of the No. 10 level. With improved methods already in operation the New Idria mine produced quicksilver in 1916 at a considerable reduction in cost, notwithstanding the fact that all new improvements and installations were charged against operating costs and amounted to over $70,000.

*San Luis Obispo County.*—The Little Bonanza mine made a small output in 1916, but the Rinconada was not operated. The old Cambria mine produced until July, after which it was closed down indefinitely. The Oceanic again produced a large quantity of low-

grade ore, from which it made a notable output of quicksilver from the Scott furnace. During part of the year Boston interests held an option and expended a large amount of money on surface and underground work and a concentration plant but obtained a very small return, and the option lapsed and the mine and mill were closed in October for the year. The Klau mine was equipped with an additional bench of 12 pipes in the Johnson-McKay retort plant and made a production in 1916.

*Santa Barbara County.*—The Red Rock mine, in the Acachuma district, made a small output from its pipe retort, but operations were limited by lack of capital to develop the ore available and provide larger reduction works. The Los Prietos mine, on Santa Ynez River, also made a small production before the property was sold to the Tungsten Mines Co., of Los Angeles.

*Santa Clara County.*—The New Guadalupe and New Almaden mines continued production in 1916. The New Almaden has been the largest producer in America to date, but operations in recent years have been much less productive than formerly. In 1916, however, extensive improvements were in progress, including a concentrating plant and a Herreshoff furnace, and with new ore from the Senador workings and old low-grade dumps and furnace material from earlier operations a continued production was expected.

*Siskiyou County.*—Experiments on a considerable scale were made at the Minnie Ha Ha mine to concentrate the surface material by washing, but much of the fine material was lost in the sluice boxes and the cinnabar content of the concentrates saved was too low to continue operations, and work was stopped in July.

*Solano County.*—The St. Johns mine continued production from a large output of ore treated in the two old 15-ton Neat furnaces and the new 20-ton Scott furnaces. Considerable development work was done in the mine, and gasoline power was installed for tramming the ore.

*Sonoma County.*—The Eureka mine made a small production from old dump ore treated in retorts, and the Culver-Baer mine was operated after June, producing metal from the Scott 24-ton fine-ore furnace, the 14-ton coarse-ore furnace, and the D-retort used for treating furnace soot. The Great Eastern was operated extensively and made a considerable output from a large quantity of low-grade ore from open cuts and stopes reduced in the Scott fine-ore and Knox coarse-ore furnaces, and a small recovery also from old furnace material treated in a D-retort. The Cloverdale mine had a large output of ore, which was treated in the improved Livermore furnace, and made a considerable production of quicksilver in 1916. The Buckeye was operated during February only and on a small scale, and the Socrates made a nominal output from sampling the mine and treating the ore samples in D-retorts. The New Sonoma mine, at Pine Flat, also made a small production from D-retorts.

*Stanislaus County.*—The Phoenix mine, in the Red Mountain district, was operated until June, 1916, and produced quicksilver from a considerable quantity of ore treated in a 40-ton Scott furnace.

*Trinity County.*—Incidental to tearing down the old furnace for rebuilding in another locality a nominal output of quicksilver was made from old furnace material at the Altoona mine.

## NEVADA.

The production of quicksilver in Nevada in 1916 was 2,198 flasks, valued at $276,706, of which 605 flasks were from retorts and 1,593 flasks from shaft furnaces. The quantity of ore treated was 12,911 tons, of which 1,569 tons was reduced in retorts and 11,342 tons in shaft furnaces. In 1915 the output was 2,327 flasks, valued at $199,657, from 21,975 tons of ore.

*Elko County.*—In the Ivanhoe district, 17 miles east of Gold Circle, a number of locations were made and some development work was done, but no production resulted in 1916. The Ivanhoe cinnabar claims were prospected, and a small quantity of ore was taken out. On the Davis and Roseberry groups chalcedony carrying cinnabar was found at and near the surface, and assays are reported to show a quicksilver content ranging from 0.79 to 16 per cent. The property was equipped with 6 Rocca retorts of half a ton capacity each. The United States cinnabar prospects were awaiting development.

*Humboldt County.*—At the Goldbanks mine, in the Goldbanks district, a large quantity of ore was mined and treated in the new Herreshoff furnace designed by W. G. Adamson, the general manager, and a good initial production was made. At the Lovelock mines, near Lovelock, a small output was made during the last three months of the year. The Rochester mine, near Rochester, made a small output also, but the property was idle most of the year owing to difficulty in marketing the product. The Bryson option on the Pitt & Taylor prospect yielded a nominal output from a short operating season. The Ranger group of claims, in the Black Rock mining district, was prospected, and surface showings indicated a wide distribution of chalcedonic silica and rhyolite breccia containing cinnabar. The interesting occurrence of cinnabar on native sulphur was also reported from these claims. The property awaited capital for further development.

*Mineral County.*—The Cinnabar King property, in the Mina district, was under development and made a small production from a D-retort. The Red Devils was actively worked and made a considerable output from retorts, and the Lost Steers was also a producer from a considerable quantity of ore mined and treated in a D-retort.

*Nye County.*—Near Beatty a nominal output only was made from the Telluride property by retorting concentrates from low-grade ore run over Wilfley tables. Operations were suspended owing to litigation. In the Ione district a large quantity of ore was mined at the Mercury mine and treated in the 25-ton Scott furnace, yielding a considerable output, and underground work was chiefly by tunnel to tap the ore 160 feet below earlier workings. At the Nevada Cinnabar mine development work was done 300 feet to the east of the main ore body, which had been worked out, and prospecting was carried on next the narrow obsidian flow. A large quantity of low-grade ore was put through the 50-ton Scott furnace and yielded good production.

## OREGON.

In Oregon considerable prospecting work was done upon claims in several counties, but outside of Lane County the quantity of ore mined and treated was only that of the early development stage.

*Curry County.*—At the Fern prospects, near Kirby, 7 claims were located and some preliminary work was done, but further work awaited capital for development.

*Douglas County.*—The old Elkhead quicksilver mine, last worked 25 years ago, was reopened and some development work was done.

*Lane County.*—The Black Butte mine was reopened in 1916, and operation of the furnace was begun in May after an idleness of several years. A large quantity of low-grade ore was mined and treated in the 40-ton Scott furnace and made a considerable yield of metal. An experimental concentration plant was under construction.

*Jackson County.*—In the Meadows district a considerable amount of development work was done on the Mountain King property and pannings showed wide distribution of cinnabar and native quicksilver, but production awaited capital for further development and a reduction plant. On the Little Jean a small quantity of rich ore from development work was retorted, which yielded a few flasks of metal. On the Mrs. Dewey some prospecting was done, and development work on the Blue Jay and Rainier claims of the Utah group yielded some rich ore that was retorted. On the Cinnabar claim also some preliminary work was done.

*Josephine County.*—On the Slide Gulch claims, near Ashland, some development produced a small quantity of quicksilver from ore treated in a D-retort.

## TEXAS.

The production of quicksilver in Texas from 1899, the beginning of output, to 1910, inclusive, was 44,476 flasks, from several properties but chiefly from the Marfa and Mariposa and the Chisos mines. From 1911 to 1915, inclusive, the output was from a single mine and has been included in these reports with that from other States. In 1916 Texas produced, again from several mines, 6,306 flasks, valued at $793,862, from 25,945 tons of ore, all treated in shaft furnaces of Scott construction and type.

*Brewster County.*—Quicksilver mining in Texas has been confined to the southern part of Brewster County, along the Mexican border, and almost wholly to the Terlingua district. The Big Bend mine, near Study Butte, was reopened in 1916 and produced a large quantity of low-grade ore, which was treated in the 50-ton Scott furnace and yielded a notable quantity of quicksilver. At the Texas-Almaden, in the same vicinity, some ore from the old dumps was put through the 20-ton Scott furnace and also produced some metal. At the "38" or old Colquitt-Tignor mine a considerable quantity of ore was treated in the 10-ton Scott furnace and had a good yield. Near McKinney Springs the Ellis property was developed late in the year and retorts were installed in 1917. At the Mariposa mine operations were begun after an idleness of several years and ore and old dumps

were treated in one of the two 10-ton Scott furnaces. New prospecting developed additional supplies, the large low-grade dumps of previous operations were found profitable to treat with high prices for quicksilver, and prospects were good for operating both furnaces at full capacity. The Chisos property was in continuous operation as in previous years and made a large output from ore mined and treated in the Scott furnace.

### WASHINGTON.

In Washington there has been some prospecting for quicksilver near Leavenworth, in Chelan County, and some prospecting, development, and production near Morton, in Lewis County.

*Lewis County.*—At the Morton property prospecting and development opened up some rich ore and a Johnson-McKay retort plant was erected and produced a small quantity of metal in the early part of 1916. Water in the property prevented further work, and operations were suspended pending a change in mining methods and the possible erection of a larger plant to treat the average ore of the property, which is of low grade. At the Mother Lode workings a considerable amount of prospecting and development work was done and some ore was taken out, but production awaited the erection of a reduction plant.

## WORLD'S PRODUCTION.

The following table gives the estimated world's production of quicksilver from 1908 to 1916, inclusive, in flasks of 75 pounds. The figures for the United States are those of the United States Geological Survey, and the sources of information for other data are indicated. In the preparation of this table F. L. Ransome, of the United States Geological Survey, checked over and modified to some extent, in the light of later information, some of the foreign figures published in previous reports of the Survey.

*World's production of quicksilver, 1908–1916, in flasks of 75 pounds.*

[1 metric ton=29.395 flasks.]

| Country. | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|---|
| United States | 19,752 | 21,075 | 20,601 | 21,256 | 25,064 | 20,213 | 16,548 | 21,083 | 29,932 |
| Austria | [a]16,814 | [a]17,196 | [a]17,725 | [a]20,694 | [a]22,428 | [a]24,104 | [b]25,000 | [b]25,000 | [b]25,000 |
| Hungary | [c]2,289 | [c]2,098 | [c]2,641 | [c]2,339 | [c]2,494 | [c]2,606 | [b]2,500 | [b]2,500 | [b]2,500 |
| Italy | [d]20,106 | [d]22,668 | [d]26,264 | [d]28,072 | [d]29,406 | [d]29,513 | [d]31,541 | [d]28,954 | [d]32,129 |
| Russia | [f]1,389 | [g]206 | [g]118 | ..... | ..... | ..... | ..... | [h]800 | [h]1,100 |
| Spain | [i]31,382 | [i]40,933 | [i]32,892 | [i]43,912 | [i]36,921 | [i]36,619 | [i]28,000 | [i]35,925 | [j]23,367 |
| Mexico and other countries | [b]5,880 | [b]4,500 | [b]4,500 | [b]4,500 | [b]4,500 | [b]4,000 | [b]4,000 | [b]4,000 | [b]4,000 |
| | 97,642 | 108,676 | 104,741 | 120,773 | 120,813 | 117,055 | 107,589 | 118,212 | 118,028 |

[a] Statistik des Bergbaues in Osterreich, Wien.
[b] Statistics not available. Estimate only.
[c] Ungarisches statistisches Jahrbuch, Budapest.
[d] Riv. servizio min., Roma.
[e] Min. Jour., London.
[f] Statistics of the mineral industry of Russia, Petrograd.
[g] Metallgesellschaft, Frankfurt-am-Main.
[h] Statistics not available. Estimate based on oral information from Russian Special Commission to U. S. in 1917.
[i] Estadística minera de España, Madrid.
[j] Revista minera, met. y de ing., Madrid.

The output of the United States was about 20,000 flasks for the four years 1908 to 1911 and increased to 25,000 flasks in 1912, only to fall to 20,000 flasks again in 1913 and to the low point of 16,500 flasks in 1914. Stimulation of war demand and prices brought the production to 21,000 flasks in 1915 and to nearly 30,000 flasks in 1916, with the prospect of 35,000 flasks for 1917 and possibly a year or two longer.

The Austrian production, from the Idria mines chiefly, in Carniola, near the Italian border, has long been under Government control and managed with high efficiency. This is undoubtedly the main source of supply for all the Teutonic powers in their conduct of the war. The output showed an increase from about 17,000 flasks a year for the period 1908 to 1910, to over 20,000 flasks in 1911, 22,000 in 1912, and 24,000 in 1913. It may be assumed that the output has been at least 25,000 flasks a year during the war, although no late information is available.

The Hungarian output, chiefly as a by-product from schwatzite ores mined in the Carpathians, has been small—2,000 to 2,500 flasks each year—and is now doubtless at the larger figure, owing to war demands.

Italy has had a steadily increasing output, principally from the Monte Amiata region, in Tuscany, ranging from 20,000 flasks in 1908 to 32,000 flasks in 1916. The mines are under Government control and formerly supplied Germany with considerable quantities of the metal but now supply the London market and Italy's allies.

The Russian output, from the Donetz Basin, at Nikitovka and Gavrilovka principally, has been small and ceased entirely in 1911 to 1914. In 1915 efforts made at reviving the industry, doubtless for war needs, led to return to the earlier output.

Spain has been the largest world's producer of quicksilver for many years, chiefly from the large and rich deposits of Almaden, under Government ownership and controlled by lease by the Rothschilds of London. The ore has been cheaply mined, and the product undersold all other quicksilver on the world's markets. The highest output by any country in recent years was reached by Spain with nearly 44,000 flasks in 1911, but since then the output has fallen off to 23,000 flasks in 1916. The ore bodies of Almaden alone are reported to be so extensive, rich, and cheaply mined that Spain can easily continue to be the principal factor in the world's market for many years to come.

In Mexico, China, Turkey, and other countries there has been a small output for many years, and doubtless all these producing countries and others—for example, Peru, formerly a large producer—can increase their supplies under favorable conditions.

The estimated world's output increased from more than 97,000 flasks in 1908 to nearly 121,000 flasks in 1912, when stocks must have become very large, as indicated by decline in production to 117,000 flasks in 1913 and to 107,000 flasks in 1914; the increase to 118,000 flasks in 1915 and 1916 was probably to meet war demands.

## IMPORTS AND EXPORTS.[1]

The imports of quicksilver entered for consumption as given in the table below have come largely from Spain and Italy by way of London, but in earlier years also in part from Austria; and there is annually a small import from Mexico, chiefly from the ports of entry on the Mexican border, in part of Mexican origin and in part metal shipped originally from this country to Mexico for use in recovery of gold and silver. The figures for quantity have been computed in terms of flasks of 75 pounds.

*Quicksilver imported and entered for consumption in the United States, 1907–1916.*

| Year. | Quantity (flasks). | Value. | Year. | Quantity (flasks). | Value. |
|---|---|---|---|---|---|
| 1907 | 221 | $6,719 | 1912 | 1,103 | $39,920 |
| 1908 | 202 | 8,216 | 1913 | 2,289 | 75,361 |
| 1909 | 203 | 8,203 | 1914 | 8,198 | 271,984 |
| 1910 | 9 | 381 | 1915 | 5,625 | 282,752 |
| 1911 | 6,293 | 251,386 | 1916 | 5,659 | 515,919 |

*Quicksilver imported and entered for consumption in the United States, by ports of entry, 1916.*

| Port of entry. | Quantity (pounds). | Value. | Port of entry. | Quantity (pounds). | Value. |
|---|---|---|---|---|---|
| Alaska | 8 | $8 | Rhode Island | 750 | $968 |
| Arizona | 1,769 | 3,659 | San Francisco | 7,762 | 13,657 |
| Eagle Pass | 12,684 | 12,550 | Southern California | 75 | 100 |
| El Paso | 9,350 | 8,522 | St. Lawrence | 307 | 1,050 |
| Laredo | 51,451 | 56,692 | St. Louis | 750 | 1,015 |
| Massachusetts | 1,875 | 2,115 | | 424,396 | 515,919 |
| New York | 297,880 | 368,237 | | | |
| Philadelphia | 39,735 | 47,346 | | | |

*Quicksilver exported from the United States, 1907–1916.*

| Year. | Quantity (flasks). | Value. | Year. | Quantity (flasks). | Value. |
|---|---|---|---|---|---|
| 1907 | 5,132 | $192,094 | 1912 | 310 | $13,360 |
| 1908 | 2,996 | 124,960 | 1913 | 1,140 | 43,574 |
| 1909 | 6,802 | 266,243 | 1914 | 1,446 | 70,753 |
| 1910 | 1,923 | 91,077 | 1915 | 3,372 | 225,509 |
| 1911 | 291 | 13,995 | 1916 | 8,880 | 670,475 |

[1] Statistics of imports and exports have been compiled by J. A. Dorsey, of the United States Geological Survey, from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

*Quicksilver exported from the United States, 1916, by countries.*

| Country. | Quantity (pounds). | Value. | Country. | Quantity (pounds). | Value. |
|---|---|---|---|---|---|
| Netherlands | 4,821 | $5,096 | Santo Domingo | 88 | $90 |
| England | 246,034 | 216,301 | Dutch East Indies | 150 | 150 |
| Canada | 71,759 | 99,745 | Australia | 675 | 635 |
| Costa Rica | 164 | 181 | Denmark | 1,020 | 1,595 |
| Nicaragua | 834 | 1,298 | Ecuador | 609 | 681 |
| Brazil | 966 | 872 | Chile | 823 | 1,331 |
| Venezuela | 2,136 | 2,364 | China | 9,005 | 9,950 |
| Hongkong | 49,275 | 55,206 | British South Africa | 1,050 | 1,078 |
| Japan | 241,025 | 234,197 | Honduras | 75 | 96 |
| Mexico | 91 | 159 | British Honduras | 10 | 48 |
| Argentina | 1,636 | 1,863 | France | 325 | 487 |
| Colombia | 990 | 1,185 | Spain | 50 | 34 |
| Portuguese Africa | 1,200 | 1,256 | Sweden | 5,625 | 7,200 |
| Dutch Guiana | 615 | 630 | Guatemala | 300 | 420 |
| French Guiana | 600 | 531 | Panama | 87 | 51 |
| Peru | 2,787 | 3,933 | Salvador | 75 | 105 |
| Chosen | 150 | 150 | Philippine Islands | 352 | 381 |
| Russia in Asia | 2,700 | 2,850 | Scotland | 15,000 | 15,300 |
| Russia in Europe | 1,512 | 1,520 | | | |
| Cuba | 1,422 | 1,506 | | 666,027 | 670,475 |

## PRICES.

Prices of quicksilver in the United States may be studied from average quotations for domestic quicksilver at San Francisco, the market in closest contact with the industry. From the low average of $39.60 a flask in 1907 the price gradually climbed to $46.51 a flask in 1910 and then declined to $40.23 a flask in 1913. On the outbreak of the war conditions of foreign embargoes and increased domestic demand brought the average up to $125.89 a flask for 1916. The price in New York usually represents an increase commensurate with cost of freight from the mines to New York. The London prices (for Spanish and Italian, but principally the former) increased from the equivalent of $39.61 a flask in 1912 to $86.39 in 1916. Since 1913 the import tariff on quicksilver has been 10 per cent ad valorem, so that for comparison of cost of Spanish and Italian quicksilver at New York with domestic there should be added the tariff plus ocean freight.

Prices given in the following tables are taken from the Mining and Scientific Press for domestic metal at San Francisco and from the Engineering and Mining Journal for the New York and London markets.

*Average yearly prices of quicksilver per flask of 75 pounds, in the United States and London, 1907–1916.*

| Year. | San Francisco (domestic). | New York. | London. |
|---|---|---|---|
| 1907 | $39.60 | $41.50 | ..... |
| 1908 | 44.17 | 44.84 | ..... |
| 1909 | 45.45 | 46.30 | ..... |
| 1910 | 46.51 | 47.06 | ..... |
| 1911 | 46.01 | 46.54 | ..... |
| 1912 | 42.05 | 42.46 | $39.61 |
| 1913 | 40.23 | 39.54 | 35.91 |
| 1914 | 49.05 | 48.31 | a 34.80 |
| 1915 | 85.80 | 87.01 | a 71.78 |
| 1916 | 125.89 | 125.49 | 86.38 |

a January—July, 1914, inclusive.

The following table shows the average monthly quotations for 1914, 1915, and 1916 for San Francisco (domestic), as published in the Mining and Scientific Press:

*Prices of domestic quicksilver per flask of 75 pounds at San Francisco, 1914–1916.*

| Month. | 1914 | 1915 | 1916 |
|---|---|---|---|
| January | $39.25 | $51.90 | $222.00 |
| February | 39.00 | 60.00 | 295.00 |
| March | 39.00 | 78.00 | 219.00 |
| April | 38.90 | 77.50 | 141.60 |
| May | 39.00 | 75.00 | 90.00 |
| June | 38.60 | 90.00 | 74.70 |
| July | 37.50 | 95.00 | 81.20 |
| August | 80.00 | 93.75 | 74.50 |
| September | [a]76.25 | 91.00 | 75.00 |
| October | 53.00 | 92.90 | 78.20 |
| November | 55.00 | 101.50 | 79.50 |
| December | 53.10 | 123.00 | 80.00 |

[a] Market fluctuated greatly at outbreak of European war.—H. D. McC.

## LITERATURE.

Lists of references to the literature on quicksilver for the North American continent have been given in previous reports in Mineral Resources, for 1910 and 1911 particularly, and a new and complete list was planned for this report. This was undertaken at the writer's suggestion by Miss Isabel P. Evans, of the United States Geological Survey, and her work was so thorough and the list is so complete that it was decided to publish it with the report for 1917 by Mr. Ransome.

# COBALT.

By FRANK L. HESS.

## GENERAL CONDITIONS.

No cobalt is known to have been produced in the United States in 1916. That used in this country was imported from Canada, where it is obtained as a by-product from silver ores mined in the Cobalt district. Three smelters at Deloro, Thorold, and Welland, Ontario, reduced the metal in 1916.

Cobalt is used in this country principally as a part of stellite, made by the Haynes Stellite Co., at Kokomo, Ind. A smaller quantity is used in high-speed tool steels. The price of the metal in 1916 ranged, according to best obtainable reports, between $1.25 and $1.50 a pound.

Ontario is the principal producer of cobalt, and the provincial government has fostered an investigation of the metal. The fourth and fifth numbers of a series of monographs on the technology of cobalt were issued during the year 1916 by the Mines Branch, Department of Mines, Ottawa, Canada. These monographs are as follows:

Kalmus, H. T., Day, C. W., Harper, C., Savell, W. L., and Wilcox, R., Preparation of metallic cobalt by reduction of the oxide, 36 pp., 8 pls., 1913.

Kalmus, H. T., and Harper, C., The physical properties of the metal cobalt, 48 pp., 14 pls., 7 figs., 1914.

Kalmus, H. T., Harper, C. H., and Savell, W. L., Electroplating with cobalt, 69 pp., 4 figs., 1915.

Kalmus, H. T., and Blake, K. B., Cobalt alloys with noncorrosive properties, 37 pp., 31 pls., 7 diagrams, 1916.

——— Magnetic properties of cobalt and of $Fe_2Co$, 18 pp., 1 pl., 13 figs., 1916.

Two patents for cobalt steel were issued in 1916 to Radclyffe Furness and Richard H. Patch. The first (United States patent No. 1206833) covers "A high-speel tool steel containing the following ingredients in the proportions specified: Carbon less than 1 per cent, chromium 2.5 to 5 per cent, molybdenum 4 to 11 per cent, and cobalt 2 to 20 per cent." The second (United States patent No. 1206834) covers a preferred composition as follows: Chromium 4 per cent, tungsten 13.5 per cent, vanadium 1.5 per cent, cobalt 15 per cent, iron 65 per cent, carbon 0.65 per cent. The range of the ingredients may be chromium 2 to 6 per cent, tungsten 9 to 15 per cent, cobalt 5 to 20 per cent, vanadium 1 to 2 per cent, carbon 0.55 to 0.75 per cent.

## CANADIAN PRODUCTION.

The production of cobalt and cobalt oxide in Canada during the last five years is shown in the following table:

*Cobalt and cobalt oxides produced in Canada, 1912–1916.*[a]

| Year. | Metallic cobalt. | | Cobalt oxide. | | Mixed oxides of cobalt and nickel and other cobalt material. | |
|---|---|---|---|---|---|---|
| | Quantity (pounds). | Value. | Quantity (pounds). | Value. | Quantity (pounds). | Value. |
| 1912 | ..... | ..... | 257,677 | $128,843 | 1,285,280 | $163,968 |
| 1913 | ..... | ..... | 660,079 | 525,028 | 3,216,000 | 90,266 |
| 1914 | ..... | ..... | 899,027 | 571,710 | 2,079,001 | 79,995 |
| 1915 | 211,610 | $197,994 | 423,717 | 338,273 | ..... | ..... |
| 1916 | 215,215 | 200,888 | 670,760 | 542,341 | ..... | ..... |

[a] McLeish, John, Annual report on the mineral production of Canada during the calendar year 1916, p. 38, Ottawa, 1918.

## IMPORTS.

The following table is made up from statistics compiled by the Bureau of Foreign and Domestic Commerce:

*Cobalt oxide, cobalt ore, and zaffer imported for consumption in the United States, 1907–1916.*

| Year. | Quantity (pounds). | Value. | Year. | Quantity (pounds). | Value. |
|---|---|---|---|---|---|
| 1907 | 48,013 | $74,849 | 1912 | 791,242 | $83,080 |
| 1908 | 219,098 | 17,677 | 1913 | 209,306 | 95,735 |
| 1909 | 12,132 | 11,096 | 1914 | 334,556 | 274,538 |
| 1910 | 14,935 | 6,352 | 1915 | 208,047 | 219,111 |
| 1911 | 602,454 | 59,151 | 1916 | 343,409 | 367,245 |

# MOLYBDENUM.

By FRANK L. HESS.

## PRODUCTION.

The production of molybdenum in 1916 was the largest yet recorded in the United States and amounted to 103.37 tons[1] of metal in 1,228 tons of ore and concentrates, valued at $205,000, as against a production in 1915 of 90.88 tons of metal in ore and concentrates valued at $114,866.

*Arizona.*—As in 1915, Arizona furnished the greater part of the output of both molybdenite and wulfenite. The wulfenite, which supplied most of the molybdenum, came from Mammoth and Shultz. The Arizona Rare Metals Co. continued to work at Mammoth on the old dumps of the Mammoth gold mine, which is at Shultz, about 40 miles north of Tuscon, Ariz. There is no water at Shultz, and therefore the ore was transported to Mammoth on San Pedro River, 3 miles away, where it was treated by crushing and amalgamation. Some years later the tailings were treated by cyanidation, and still later they were run through sluice boxes to save the wulfenite. The ore had been so finely crushed that the friable particles of wulfenite were too small to be easily saved, but some concentrate was obtained. The tailings were spread over a considerable area of ground and lay so long undisturbed that they had been in part farmed as if they were soil. R. O. Boykin then sampled and later, with Frank H. Hereford, bought them, formed the Arizona Rare Metals Co., and erected a mill in which the company has continued to work the tailings.

The Mammoth mine, which had long lain idle, was taken over by Col. Epes Randolph and associates under the name of the Mammoth Development Co., and work on it was begun in 1916. The mine had been worked down to about 760 feet—somewhat below water level With the Mammoth, the Collins mine, a few hundred feet west, was also taken over. The mines are in brecciated zones, 10 to 20 feet across and even wider, in granite and later porphyries. The broken rock is loosely cemented and in the cracks are wulfenite crystals. With the wulfenite is some vanadinite, descloizite, cuprodescloizite and, in the Collins mine, considerable cerusite. The wulfenite is yellow, brownish yellow, carrot-red, brownish red, and bright red. The crystals bristle from the fragments of the breccia so that the light from a lamp is reflected from thousands of facets, causing a marvelously beautiful effect. The stopes hold up almost without timber, even though so loosely cemented. Not nearly so much work has been done in the Collins mine as in the Mammoth mine.

[1] The short ton of 2,000 pounds is used throughout this article.

A few hundred feet east of the Mammoth mine the old Mohawk mine, also worked for gold, reaches a depth between 600 and 700 feet from the surface, which here is considerably below that of the Mammoth and the Collins. The Mohawk has lain idle for years. Several of the upper levels have large stopes with thousands of tons of broken ore ready for removal, but apparently too lean in gold to be worked for that metal. The stopes have the same beautiful appearance in the lamplight as those of the Mammoth but appear from inspection without sampling to be less rich and to contain a larger proportion of vanadinite. The mine has not yet been worked for these minerals, but the appearance of the stopes suggests the possibility of drawing the broken ore at a profit, even if no other work could be done, provided, of course, that a market could be found for the concentrates. Although no tungsten mineral has yet been identified in the mines the concentrates are said to carry as much as 2 per cent $WO_3$.

The Old Yuma mine, which was worked by Col. Epes Randolph for wulfenite in 1915, proved to be less rich than expected and was soon worked out.

Molybdenite was produced by several mines in Arizona. The Leviathan Mines Co., in Copper Canyon, a tributary of Deluge Wash, on the east side of the Hualpai Mountains, 25 miles southeast of Yucca and between 50 and 60 miles by road south of Kingman, has a large quartz vein 20 feet or more in width, carrying molybdenite, pyrite, and chalcopyrite. The vein cuts granite close to its original surface. The Leviathan Co. mined ore and sold it to the American Molybdenum Co., which has a mill a mile south at the junction of the canyon with Deluge Wash; here the ore was treated by oil flotation. There are numerous other molybdenum-bearing deposits in the vicinity, but they were nonproductive in 1916.

The Helvetia Copper Co. produced a considerable quantity of high-grade molybdenite ore as a by-product in mining copper at Helvetia.

*California.*—In California some high-grade molybdenite ore was hand picked by J. H. Sproul from a deposit near Bishop.

*Utah.*—In Utah molybdenite ore was mined from a deposit on the south side of Little Cottonwood Canyon about 1½ miles below Alta and 35 miles southeast of Salt Lake City. The ore is a peculiar impregnation in granite, the grains of the granite being coated by molybdenite in such a way as to give the impression that the ore is much richer than it really is. It is accompanied by pyrite and a little chalcopyrite.

*New Mexico.*—A small quantity of rich molybdenite concentrate was made by the Romero Mining Co., near Porvenir, San Miguel County, N. Mex., from a deposit in which the molybdenite is apparently contained in a pegmatite and is associated with chalcopyrite, scheelite, bismuth minerals, and fluorite.

## GENERAL CONDITIONS.

The molybdenum situation is always very hard to define because the demand is small, most buyers are very secretive about the disposition of their purchases or manufactured products, and inquirers for the ore usually surround their dealings with an air of mystery.

There are, however, notable exceptions, men whose courteous helpfulness the United States Geological Survey gratefully acknowledges.

The actual uses as now developed for the metal are small. In this country the use of molybdenum in tool steels, according to reports received by the Geological Survey from various sources, has decreased. A small quantity is used in electric work, for supports for tungsten filaments in incandescent lamps, in Roentgen ray apparatus, and in small resistance furnaces; a number of tons of ore is consumed in making ammonium molybdate for use in chemical work; and a little is used in some stellite; but outside of these practically no uses are known. Efforts have been made to use the blue oxide in dyes, but the process is not known to have been adopted on a commercial scale, although stated in certain papers as a prominent use. Statements that molybdenum is used in smokeless powder, gun steels, and armor plate are constantly reiterated and as positively denied.

Abroad molybdenum is apparently used in steel much more than in this country, and it is commonly accepted that the decided rise in price was caused by German buyers taking available supplies a few months before the beginning of the war. French and English steel makers are apparently now using the metal to some extent to replace tungsten, which they have had difficulty in obtaining.

The market in this country has heretofore been so small that when a broker is commissioned to purchase 50 tons or more of metallic molybdenum and he begins to hunt for a supply, his inquiries go to numerous persons, and the impression soon gains ground that there is a large demand. The Geological Survey is greatly interested in seeing an extension of the market and will do what it may in bringing producer and buyer together, but frequent publication of inaccurate reports of uses and demands serves no good purpose.

Separate figures showing imports and exports of molybdenite are not compiled by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

# NICKEL.[1]

By FRANK L. HESS.

## PRODUCTION.

Although the United States is the largest refiner of nickel it is almost a nonproducer of nickel ore. No nickel ore was mined in this country in 1916, but as usual a small output of the metal, amounting to 918 short tons and valued at $671,192, was saved as a by-product from the electrolytes in the electrolytic copper refineries. The output from this source since 1911 is shown in the table below:

*Nickel content of nickel salts and metallic nickel produced as by-product in electrolytic refining of copper, 1911–1916.*

| Year. | Quantity (short tons). | Value. | Year. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| 1911 | 445 | $127,000 | 1914 | 423 | $313,000 |
| 1912 | 328 | 93,600 | 1915 | 822 | 538,222 |
| 1913 | 241 | 79,393 | 1916 | 918 | 671,192 |

As usual, the great bulk of the nickel imported was in matte from the International Nickel Co.'s smelter at Copper Cliff, Ontario, the ores coming from the company's mines at Sudbury. The mines and smelter in Canada are operated by a subsidiary company known as the Canadian Copper Co. The matte, which in 1916 carried 51.6 per cent of nickel, is shipped for refining to another subsidiary, the Orford Copper Co., at Bayonne, N. J. Matte from New Caledonia is refined by the United States Nickel Co., at New Brunswick, N. J.

Imported nickel ore and nickel matte are specifically exempted from duty,[2] but imported "nickel, nickel oxide, alloy of any kind in which nickel is a component material of chief value, in pigs, ingots, bars, rods, or plates" must pay a duty of 10 per cent ad valorem; sheets or strips, 20 per cent.[3]

## IMPORTS.

The imports of nickel for consumption in the United States since 1910, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, have been as follows:

[1] An epitome of the known nickel deposits in the United States was published in Mineral Resources, 1915, pt. 1, pp. 747–757, 1917.
[2] Tariff act of Oct. 3, 1913, sec. 565.
[3] Idem, sec. 155.

*Nickel imported for consumption in the United States, 1910–1916.*

| Year. | Nickel, nickel ore and matte, nickel oxide, alloys of nickel with copper, etc.[a] | | Value of manufactured articles of nickel and nickel sheets and strips. | Total value. |
|---|---|---|---|---|
| | Quantity. | Value. | | |
| | *Pounds.* | | | |
| 1910 | 32,363,351 | $4,213,079 | $14,759 | $4,227,838 |
| 1911 | 29,829,368 | 4,022,716 | 27,314 | 4,050,030 |
| 1912 | 44,317,078 | 5,724,431 | 34,536 | 5,758,967 |
| 1913 | 47,446,520 | 6,562,555 | 38,200 | 6,600,755 |
| 1914 | 35,098,958 | 5,000,594 | 28,224 | 5,028,818 |
| 1915 | 56,599,381 | 7,629,686 | 6,458 | 7,636,144 |
| 1916 | 72,649,377 | 9,899,340 | 25,880 | 9,925,220 |

[a] Includes only the nickel content of ore and matte. No ore is known to have been imported into the United States in 1911, 1912, or 1913.

*Nickel imported for consumption in the United States, 1914–1916, by forms.*

| Form. | 1914 | | 1915 | | 1916 | |
|---|---|---|---|---|---|---|
| | Quantity (pounds). | Value | Quantity (pounds). | Value. | Quantity (pounds). | Value. |
| Nickel, alloys, pig, bars, etc | 106,019 | $42,678 | 31,990 | $13,557 | 29,917 | $7,869 |
| Ore and matte (nickel content) | 34,989,745 | 4,956,448 | 56,566,594 | 7,615,999 | 72,611,492 | 9,889,122 |
| Nickel oxide | 3,194 | 1,468 | 497 | 130 | 7,968 | 2,349 |
| Nickel sheets or strips | | 6,851 | | | | 4,996 |
| Nickel, all other manufactures of | | 21,373 | | 6,458 | | 20,984 |
| | 35,098,958 | 5,028,818 | 56,599,381 | 7,636,144 | 72,649,377 | 9,925,220 |

*Nickel ore and matte imported into the United States in 1916, by country of origin.*

| Country. | Quantity. | Nickel content. | Value. |
|---|---|---|---|
| | *Short tons.* | *Pounds.* | |
| Canada | 62,042 | 68,487,279 | $9,021,979 |
| Australia (Tasmania) | 2,752 | 2,387,101 | 507,517 |
| French Oceania (New Caledonia) | 2,116 | 1,737,112 | 359,626 |
| | 66,910 | 72,611,492 | 9,889,122 |

## EXPORTS.

The United States refines much more nickel than it uses, so that though not a large producer it is a large exporter.

*Nickel, nickel oxide, and matte[a] exported from the United States, 1910–1916.*

| Year. | Quantity. (pounds). | Value. | Year. | Quantity (pounds). | Value. |
|---|---|---|---|---|---|
| 1910 | 15,244,937 | $4,704,088 | 1914 | 27,595,152 | $9,455,528 |
| 1911 | 25,099,586 | 8,283,777 | 1915 | 26,418,550 | 10,128,514 |
| 1912 | 25,815,016 | 8,515,332 | 1916 | 33,404,011 | 12,952,498 |
| 1913 | 29,173,088 | 9,686,794 | | | |

[a] No nickel matte is known to have been exported in the years 1911 to 1916, inclusive.

Manufactures of nickel valued at $1,764,600 were also exported.

During 1916 the German submarine *Deutschland* twice landed in this country and took from it cargoes of material. Of these, nickel formed a considerable part. The cargoes are of interest to thoughtful Americans, showing the things that, given a small cargo space, seemed most important to the Germans at that time. The materials carried were as follows:

*Outbound cargoes of submarine Deutschland in July and December, 1916.*

**July.**

| Material. | Quantity (pounds) | Value. |
|---|---|---|
| Pig tin | 348,706 | $209,223 |
| Ferrovanadium | 30,825 | 69,522 |
| Nickel | 752,674 | 376,337 |

**December.**

| | | |
|---|---|---|
| Nickel | 415,412 | $207,706 |
| Tungsten | 55,125 | 137,812 |
| Ferrochrome | 335,400 | 47,080 |
| Ferromolybdenum | 100 | 176 |
| Other iron alloys | 314 | 1,454 |
| Rubber (414 measured tons) | 802,037 | 568,855 |

## CANADIAN NICKEL PRODUCTION.

As shown by the figures of imports already given, much the greater part of the nickel refined and used in the United States comes from Canada. The following excerpts are from an article by John McLeish, chief of the division of mineral resources and statistics, Mines Branch, Canada Department of Mines.[1]

The industry based on the mining and metallurgical treatment of the nickel-copper ores of the Sudbury district, Ontario, ranks among the most important of Canada. Not only is there a considerable production of copper, but the nickel, which is the important product, supplies a very large proportion of the world's consumption of the metal.

The past few years development has very largely increased the known ore reserves of the district. These nickel-copper deposits have been the subject of special reports by the Mines Branch and Geological Survey at Ottawa, by the Ontario Bureau of Mines, Toronto, and just recently by the Royal Ontario Nickel Commission.[2]

The production of nickel in 1916 amounted to 82,958,564 pounds, valued at $29,035,497, as compared with 68,308,657 pounds, valued at $20,492,597, in 1915, an increase of 21.4 per cent over that of 1915, and of 82.2 per cent over the production of 1914.

There were mined in 1916, 1,566,333 tons of ore, and smelted 1,521,689 tons, from which were produced 80,011 tons of Bessemer matte, carrying approximately 41,298 tons of nickel and 22,430 tons of copper. The net value of the matte, as reported by operators, was $12,116,333, which is based on an average value of 7.2 cents per pound for the copper and 10.8 cents per pound for the

[1] Mineral production of Canada during the calendar year 1916: Ann. Rept., pp. 129–134, Ottawa, 1918.

[2] Barlow, A. E., Report on nickel and copper deposits of Sudbury, Ontario: Canada, Geol. Survey, No. 873, 1901.

Coleman, A. P., The Sudbury nickel region: Canada Bur. Mines, vol. 14, pt. 3, 1904; The nickel industry, with special reference to the Sudbury region, Ontario: Canada Dept. Mines, Mines Branch, No. 170, 1918. Royal Ontario Nickel Commission Rept. with Appendix, Toronto, 1917.

nickel. The average metal recovery in matte from the ores treated was 1.474 per cent of copper and 2.741 per cent of nickel, as against 1.541 per cent of copper and 2.675 per cent of nickel in 1915.

The nickel-copper ore is reduced in smelters and converters to a Bessemer matte, containing from 77 to 82 per cent of the combined metals; in 1916 it averaged 51.6 per cent of nickel and 28.0 per cent of copper, as against 50.3 per cent of nickel and 29.0 per cent of copper in 1915; 49.0 and 31.1, respectively, in 1914; and 52.7 and 27.4, respectively, in 1913.

For the production of monel metal a special matte is produced with contents of about 22 per cent of copper and 58 per cent of nickel, which is included in the total given above. Monel metal is produced directly from this matte without the intermediate refining of either the nickel or the copper.

* * * * * * *

Refined metallic nickel is now being recovered in Canadian refineries but only in small quantities and as a by-product in the smelting and refining of the silver-cobalt-nickel ores, nickel-oxide having been recovered in these smelters for several years. The recovery of nickel sulphate was also reported for the first time in 1915. A considerable amount of nickel is probably contained in ores exported for smelting, for which no payment is received by the mines shipping, and the amount finally recovered is impossible to ascertain.

The production of metallic nickel during 1916 was reported as 79,360 pounds, valued by the operators at $31,538, as against 55,325 pounds, valued at $22,130, in 1915; that of nickel-oxide and nickel-sulphate was reported as 555,868 pounds, valued at $101,358, as against 282,025 pounds, valued at $31,262, in 1915.

The total estimated nickel content of recoveries from silver-cobalt-nickel ores in 1916 was 361,702 pounds, as against 231,634 pounds in 1915.

The companies engaged in mining and smelting nickel ores are:

The Canadian Copper Co., subsidiary to the International Nickel Co., with smelter at Copper Cliff, Ontario, and refinery at Bayonne, N. J. This company is erecting a new refining plant at Port Colborne, Ontario, which will probably be in operation late in 1917.

The Mond Nickel Co., of London, England, with smelter at Coniston, Ontario, and refinery at Clydach, Swansea, Wales.

The British American Nickel Corporation (Ltd.), which started erecting a smelter and refinery at the Murray mine late in 1916, although not shipping during the year, development was actively carried on.

The Alexo Mining Co. (Ltd.), which operated its mine at Porquis Junction on the Porcupine branch of the Timiskaming & Northern Ontario Railway, shipping nickel-copper ore to the Mond smelter at Coniston.

Nickel was recovered as a by-product in the smelters at Deloro, Thorold, and Welland, from the silver-cobalt-nickel ores of the Cobalt district. * * *

*Exports and imports.*—The exports in 1916 amounted to 80,441,700 pounds, of which 11,136,900 pounds, or 13.8 per cent, went to Great Britain, and 69,304,800 pounds, or 86.2 per cent, to the United States. In 1915, 20.7 per cent of the total went to Great Britain, and 79.3 per cent to the United States; and in 1914, 22.1 per cent went to Great Britain, and 77.4 per cent to the United States.

The exports to the United States, which had fallen off nearly 20 per cent in 1914, showed an increase in 1915 of over 46 per cent, and in 1916 of over 31 per cent.

*Exports of nickel, 1912–1916.*

| Destination. | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|
| Great Britain.....pounds.. | 5,072,867 | 5,164,512 | 10,291,979 | 13,747,991 | 11,136,900 |
| United States.....do.... | 39,148,993 | 44,224,119 | 36,015,642 | 52,662,451 | 69,304,800 |
| Other countries.....do.... | ..... | 70,386 | 220,706 | ..... | ..... |
| | 44,221,860 | 49,459,017 | 46,528,327 | 66,410,442 | 80,441,700 |

*Bounty on refined nickel and nickel-oxide.*—Under the terms of "the metal refining act, 1907," of the Province of Ontario (7 Edward VII, chap. 14) a bounty is authorized to be paid on nickel, cobalt, copper, and arsenic under certain conditions and restrictions during a period of five years following the

passing of the act (April, 1907). In March, 1912, the act was amended to cover a further period of five years.

The sections affecting nickel are as follows:

"The treasurer of the province may under the authority of such regulations as may from time to time be made in that behalf by the lieutenant governor in council pay in each year to the refiners of the metals or metal compounds hereinafter specified when refined in the Province from ores raised and mined in the Province, a bounty on each pound of such metal or compound so refined, as follows:

"Class 1.—On refined metallic nickel or on refined oxide of nickel, 6 cents per pound on the free metallic nickel or on the nickel contained in the nickel-oxide, but nickel on which a bounty has already been paid in one form of product shall not be entitled to any further bounty in any other form, and the amount to be paid as bounty on the nickel products therein mentioned is not to exceed in all $60,000 in any one year."

## PRICES.

Prices on nickel to large steel works seem to have ranged, according to the best information available, between 35 and 38 cents a pound for refined nickel and 5 cents higher for electrolytic nickel. The published quotations which seemed to apply to purchasers who bought less and were not on long-time contracts ranged between 40 and 45 cents a pound for the first seven months and 45 and 50 cents for the last five months, with an added 5 cents for electrolytic nickel.

# TITANIUM.

By Frank L. Hess.

Rutile, titanium dioxide ($TiO_2$), and ilmenite, titanium iron oxide ($TiFeO_3$), were produced in this country in 1916 only by the American Rutile Co., at Roseland, Nelson County, Va.[1] The company sold 110 tons of rutile concentrates carrying 95 per cent of $TiO_2$ for $16,500 and 95 tons of ilmenite concentrates carrying 55 per cent of $TiO_2$ for $1,900. The ilmenite is obtained as a by-product of the rutile.

The Titanium Alloys Manufacturing Co., Niagara Falls, N. Y., is understood to have imported a considerable quantity of ilmenite from Baie St. Paul, Quebec, from which it manufactured ferrotitanium in the electric furnace. The only other manufacturer of ferrotitanium in this country is the Goldschmidt Thermit Co., of New York City. One product contains carbon and the other aluminum, and there has been a lively dispute as to the relative merits of the products, both of which are used in steel as a deoxygenizer and to remove other impurities.

Buckman & Pritchard (Inc.) erected a plant in 1916 to extract ilmenite, rutile, and monazite from the beach sands about 4 miles south of Pablo Beach, Fla., the nearest beach to Jacksonville, but made no production during the year. These and other heavy minerals, including zircon, garnet, epidote, kyanite, and others, have been concentrated on a slightly cuspate beach similarly to the concentration near Nome, Alaska, Coos Bay, Oreg., and Monterey Bay, Cal., the monazite sands of Brazil, and the sands on many other beaches. The material has probably come from the gneisses and pegmatites of the southern Appalachians and was washed down through what is now Georgia and Florida, and the débris has been worked and reworked over and over by stream and ocean.

A total of 112 short tons of ferrotitanium, valued at $8,126, was imported for consumption in 1916.

[1] The rutile deposits of Virginia are described in the following works: Watson, T. L., and Taber, Stephen, Geology of the titanium and apatite deposits of Virginia: Virginia Geol. Survey Bull. 3–a, 308 pp., 37 pls., 22 figs., Charlottesville, 1913. Watson, T. L., The rutile deposits of the United States: U. S. Geol. Survey Bull. 580, pp 385–412, 1915.

# TUNGSTEN.[1]

By FRANK L. HESS.

## PRODUCTION.

The production of tungsten ore in the United States, following a short collapse at the beginning of the great war in 1914, went forward at such a rate that the output for 1915 was greater than in any previous year and was equivalent to 2,332 short tons[2] of concentrate carrying 60 per cent of $WO_3$, and valued at $4,100,000. Interest in tungsten was increasing geometrically, and far the larger part of the product was marketed in the second half of the year. At the beginning of 1916 work was in full swing, prices had reached undreamed heights, and the production in the first half of the year was 3,290 tons, valued at $9,113,000. Prices reached their zenith in March. With the fall in prices work soon stopped on many lean deposits, and the production in the second half of the year steadily declined. The year's output was the largest ever made by any country—5,923 short tons, valued at $12,074,000.

The production of tungsten ores in the United States has been as shown in the table below. The production before 1900 was negligible.

*Concentrated tungsten ores produced in the United States, 1900–1916.*[a]

| Year. | Quantity (short tons). | Value. | Year. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| 1900 | 46 | $11,040 | 1909 | 1,619 | $614,370 |
| 1901 | 179 | 27,720 | 1910 | 1,821 | 832,992 |
| 1902 | 184 | 34,040 | 1911 | 1,139 | 407,985 |
| 1903 | 292 | 43,339 | 1912 | 1,330 | 502,158 |
| 1904 | 740 | 184,000 | 1913 | 1,537 | 672,118 |
| 1905 | 803 | 268,676 | 1914 | 990 | 435,000 |
| 1906 | 928 | 348,867 | 1915 | 2,332 | 4,100,000 |
| 1907 | 1,640 | 890,048 | 1916 | 5,923 | 12,074,000 |
| 1908 | 671 | 229,955 | | | |

[a] The production of tungsten ores in this country from year to year can be fairly compared in this table only since and beginning with 1906, as before that date no effort was made to reduce the ores to a common basis of concentration. Since 1906 the ores have been, as far as possible, reduced to an equivalent of ore carrying 60 per cent of tungsten trioxide ($WO_3$), which is the ordinary commercial basis in the United States.

[1] More extended articles on tungsten have been published in Mineral Resources for 1912 and 1914. See also Hess, F. L., Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652, 1917.

[2] The ton used in this article, unless otherwise noted, is the short ton of 2,000 pounds.

The production of tungsten ores in 1916 was as follows:

*Tungsten ores produced in the United States in 1916, in short tons.*

| State or Territory. | Ore mineral. | | | | Total. |
|---|---|---|---|---|---|
| | Scheelite. | Ferberite. | Wolframite. | Huebnerite. | |
| Alaska | 47 | | | | 47 |
| Arizona | 6 | | 144 | 68 | 218 |
| California | 2,129 | | 30 | 12 | 2,171 |
| Colorado | | 2,329 | 1 | 71 | 2,401 |
| Idaho | 71 | 1 | | 29 | 101 |
| Nevada | 516 | | | 173 | 689 |
| New Mexico | | | | 16 | 16 |
| South Dakota | | | 239 | | 239 |
| Utah | 20 | | | | 20 |
| Connecticut, Missouri, Montana, Oregon, Washington | 5 | | 10 | 6 | 21 |
| | 2,794 | 2,330 | 424 | 375 | 5,923 |

The items of the wolframite group (ferberite, wolframite, and huebnerite) necessarily encroach upon one another. Some of the ferberite from Boulder County, Colo., probably should be classed as wolframite, but that is true of only a small part of the output. Similarly some of the wolframites grade into huebnerite, and vice versa.

The production from the Boulder field is represented by the Colorado production of ferberite and exceeds the California output; but no mining district, either domestic or foreign, has yet produced a tungsten mine equal to that of the Atolia Mining Co.'s property at Atolia, Cal.

## MINING CONDITIONS.

### EXCITEMENT CAUSED BY HIGH PRICES.

In the tungsten mining camps the excitement that followed the increase of prices was like that caused by important gold discoveries. Nederland, Colo., a little village of two or three dozen homes, suddenly became a town of 3,000 or more inhabitants. Another small town grew around Lakewood, 2 miles north of Nederland. East of Nederland, along Boulder Creek, two settlements, Stevens Camp or Tungsten and Ferberite, each containing several hundred people, with the usual stores, restaurants, and places of amusement, but minus saloons, sprang into existence. Atolia, Cal., a camp of 75 or 100 people, grew to more than a thousand. Dragoon, Ariz., with a few straggling houses had 300 or 400 workers, and smaller communities arose in Las Guigas Mountains, Ariz., and at several places in Nevada.

### WORKING OF DUMPS AND PLACERS.

Old dumps in Boulder County were carefully re-sorted and the ground near veins was worked over for float. Fifteen or more jigs

were reported to have been operating on piles of old tailings and on placers. The finer tailings were sent over Wifley tables. All mills, jigs, and tables were operated by electric power, and so great was the demand for motors that the stocks in Denver were exhausted.

In the Atolia field hundreds of men dug "spuds"—pieces of float scheelite—in the Spud Patch, a stretch of desert sands southeast of the Atolia mill and roughly a mile long by a quarter to half a mile wide. From this work a vein, which produced scheelite valued at nearly $100,000 was found on a claim belonging to P. J. Osdick. The vein has the same general strike as the Flatiron, Papoose, Union, and other veins and lies east of the Atolia Mining Co.'s property. A wash runs on the west side of Red Mountain south and then southeast across this series of veins, and in this wash, in the course of an enormously long time the heavy rains that occur at rare intervals have formed streams which have worn down the veins and the inclosing granodiorite and filled a great depression with coarse sand alternating with layers of boulders that mark times of unusual floods. Under and around these boulders is the scheelite, and naturally the heaviest material is nearest the veins. One piece weighed more than 100 pounds. How many years separated these rains is indicated by the fact that men who have lived in the vicinity for 25 years or more have never seen a rain heavy enough to make a stream in the wash that would spread sand over the flat, not to mention boulders.

Most of the float has come from veins on P. M. Osdick's Skylark claims and, going westward and uphill, the Atolia Mining Co's Flat Iron and Papoose veins. From the Rainstorm, Union, and other veins little float seems to have been formed.

The scheelite-bearing gravel lies at depths which range from 2 or 3 feet near the Papoose to 55 feet on the Ed. Holtz claim. The gravels and sands are in places very much deeper, but little or no scheelite has been found lower down in them. A short distance beyond the workings a hole was sunk 250 feet without striking bedrock. Either the scheelite veins were not exposed at the time the deeper débris was deposited or the channel carrying the float has not been found. In general, the gravel is sufficiently cemented by carbonate of lime (caliche) to allow drifting without timbering, though some thin beds are loose. Miners estimated that at $20 a unit a bed 3 feet thick and 55 feet below the surface would yield wages—that is, about $4 to $4.50 a day—if it produced 15 pounds of concentrate carrying 63 per cent of $WO_3$ per cubic yard. A little cinnabar is found with the scheelite pebbles.

In Baltic Gulch, in the Stringer district, between Atolia and Randsburg, considerable placer mining was also done for scheelite. In this gulch the scheelite has come from thin veins connected with the gold veins. The gravels range in depth from 2 to more than 30 feet and carry some gold.

The scheelite from both placers is very free from impurities and of high grade. The total quantity produced, however, was not more than 100 short tons.

All water for the district is shipped in tank cars about 55 miles from Hinckley.

Placer huebnerite was mined near Spanish Springs and Round Mountain, Nev., and Dragoon, Ariz., and a little placer scheelite was saved near Nome, Alaska.

## VEIN MINING.

During the continuance of very high prices the Union mine of the Atolia Mining Co., at Atolia, Cal., was in bonanza ore, and on the seventh level nearly pure scheelite was 5½ feet thick at one place. The shoot was 675 feet long, tapering both ways and, of course, not so rich throughout. Part of the ore carried only 2 or 3 per cent of scheelite. The ore was stoped to a thickness of 8 feet and was the best so far found in the mine, which has probably been the richest tungsten mine ever discovered and, aside from the big copper and iron mines, was one of the best, if not the best, paying of the American mines in 1916. The Atolia Mining Co.'s mill burned in the early part of the year but was replaced by a larger one. Except for this accident the California production would probably have exceeded that of Colorado.

The Union Hill gold mine, at Grass Valley, Cal., produced some scheelite, and a little wolframite was produced from the Sierra Nevada, near the Minarets, in Madera County, Cal. Wolframite was also produced in the Clark Mountains, and huebnerite from the vicinity of Von Trigger and in the New York Mountains in eastern San Bernardino County.

Perhaps the most notable single development in the Boulder field in Colorado in 1916 was the taking over by the Primos Mining & Milling Co. of the Copeland property on South Boulder Creek, a mile and a half from Crescent station on the Moffat road. A mill was erected and considerable work was done on the lode, both underground and in an open cut.

A zone in granite has been replaced by exceedingly hard, tough, fine-grained red quartz, the "horn rock" of the district, which attains a thickness of 10 feet or more but fingers out into a stockwork in the open cut. A part of the vein has been faulted and ground up until the vein filling looks like loose glacial till (a mixture of gravel, boulders, and clay), but where the "horn rock" is thickest the fault has moved to the side of the vein, probably because it is so tough and hard. The red "horn rock" is cut by numerous veins of gray "horn rock" less than an inch thick and in these gray veins are buried tiny crystals of ferberite ranging in quantity from enough to darken the rock to so much that the rock is only a binder for the particles. A microscopic examination shows that some of the particles are not more than one five-hundredth of an inch in diameter. Hand-picked ore may carry 5 per cent of $WO_3$, but the mining of such hard rock is difficult and the milling and saving of the minute particles more difficult, so that although operation of the deposit was attempted years ago, the effort was given up, and the property was allowed to lie idle until the high prices made further attempts attractive.

An important development of the year was the beginning of production of scheelite from contact-metamorphic deposits near Bishop, Cal.; Toy and Toulon (near Lovelock), Nev.; and in Box Elder County, Utah. Limestones have been intruded by granite and al-

tered to heterogeneous masses of epidote, garnet, amphibolite, chlorite, and other minerals, and among them scheelite has been introduced by the solutions accompanying the granite. The shoots of ore are irregular and the scheelite is also extremely variable in the size and form of its grains. It is usually white, though it is sometimes strangely colored, as at the Ragged Top claims, near Toulon, Nev., and many specimens show a tendency to crystal form. Where garnet is present a magnetic separator gives much better results than shaking tables. The ore bodies in general carry about 1 per cent of $WO_3$.

Deposits that are unique in this country were mined for scheelite in the Deep Creek Mountains, near Gold Hill, Tooele County, Utah. Bodies of granite, replaced by masses of tourmaline needles in radial aggregates, feldspar, quartz, danburite, hornblende, and other minerals, carry scheelite accompanied by chalcopyrite, bismuth minerals, cuprotungstite (formed from the scheelite), and molybdenite. The production has not been large and does not promise to be large. The bodies are irregular and are also much faulted. Some of the bodies carry lead minerals.

Tungsten mining was begun as a new industry at Silvermine, Mo., where wolframite was extracted from an old mine once worked for silver. Galena, pyrite, and lithia mica are stated to be accompanying minerals.

A small quantity of scheelite was mined at Long Hill, 8 miles north of Bridgeport, Conn., but the mill was burned and operations ceased. It is noteworthy that tungsten ores were first mined in America at this place. The tungsten minerals seem to have been deposited as replacement minerals in a regionally metamorphosed limestone. Some scheelite crystals of good size have been replaced by wolframite. A black sphalerite accompanies the scheelite.

Deposits apparently of similar origin were worked near Fairbanks, Alaska, and part of the concentrates were shipped by parcel post.

A considerable number of tungsten deposits were found and several were worked in White Pine County along the eastern border of Nevada. At Tungstonia A. R. Shepherd, jr., and associates operated a small mill on ore taken from a large quartz vein carrying huebnerite accompanied by small quantities of sphalerite, galena, and triplite. Several smaller veins were also worked. Other veins were discovered in the neighborhood by prospectors and a mill was put up a short distance southwest of Tungstonia by the Salt Lake-Tungstonia Mines Co., and across the hills northeast, possibly 2 miles away, another mill was begun by the Utah-Nevada Mining & Milling Co., but was not finished. Southward scheelite was mined and milled on the western side of the Snake Range at Sacramento Pass and on Willard Creek, 3 miles south of Osceola. Huebnerite was mined at Tungsten, 12 miles south of Osceola, from the veins known for many years, and in a small way from newly discovered veins a mile south of Tungsten. Scheelite was mined from various veins in the Minerva district near Shoshone post office, 13 miles south of Tungsten. On the east side of the range the John D. Tilford claims on Snake Creek, 20 miles southwest of Baker, and other claims higher up Snake Creek made some production, and promising claims a few miles south on Lexington Canyon were prospected.

Tungsten ore was produced at many points in Arizona, and several hundred people flocked to Dragoon to mine placer huebnerite. A little scheelite was mined at Libby, Lincoln County, Mont., and near Baker, Baker County, and Gold Hill, Jackson County, Oreg.; some huebnerite was mined on Blue Grouse Mountain, near Loon Lake, Stevens County, and a little wolframite near Cathedral Peak, Okanogan County, Wash.

More than 40 mills of all sorts and conditions were operating or erected to operate during 1916. Unfortunately some had no ore on which to work, having been erected in advance of prospecting.

## PRICES.

The prices caused by the great need for high-speed steel tools to cut war steel for the European governments were romantically high and were of the phenomena seen only once in a lifetime.

At the beginning of 1916 prices of tungsten ore were irregular and depended on the buyer's need and probably also on his fear of not being able to get the ore when he might have even greater need for it. Ores carrying 60 per cent of tungsten trioxide brought at that time as much as $66 a unit, but by the last of March some ferberite sold for $93.50 a unit at the mill, and even higher prices were quoted in the newspapers, though they could not be confirmed. The prices of the same ore in the New York market would naturally be somewhat higher. Under the stimulus of these high prices production, not only in this country but in the world at large, was at the highest point ever known. At first the sudden demand created by the orders for war steel were far ahead of the instant productive power of the country. The rapid increase in prices, beginning in the fall of 1915 at a time when tungsten mining was at a low ebb and culminating in an undreamed maximum, caused prospecting and consequent discoveries of new deposits, the increase of development of known deposits, the operation at high tension of old mills, and the hasty building of new mills. As a result, production increased faster than consumption and soon overran the demand that would absorb the output at the extremely high prices prevailing, so that a drop in prices was inevitable. At one time ores carrying 2½ per cent of $WO_3$ sold for $20 or more a unit. June closed with the prices around $20 a unit for ore carrying 60 per cent or more of $WO_3$, and by the end of the year lots were sold for $15 a unit—a price still equal to the highest before known (in 1907). The normal price before had been $6 to $7 a unit. These prices were, of course, for concentrates carrying 60 per cent or more of $WO_3$ and free from injurious quanties of phosphorus, sulphur, tin, copper, and similar impurities. During the height of the demand, however, ores carrying all sorts of impurities and both tungsten and ferrotungsten carrying not only the same impurities but also high carbon were eagerly bought and used.

Tungsten and ferrotungsten sold for $9 and more a pound for the contained tungsten. By the end of the year they sold for about $2.50 a pound.

In the British possessions the price of tungsten ores remained, as in 1915, fixed at 55s. per long ton unit laid down in England. Aus-

tralian papers contained advertisements announcing that payments would be made as follows: Either wolframite or scheelite ores carrying 65 per cent or more of $WO_3$ from 45s. 2d. to 48s. 1d., the price depending on the field. For ores carrying between 60 and 65 per cent of $WO_3$ a penalty of 3d. for each unit (presumably below 65 per cent), and for ores carrying between 55 and 60 per cent a penalty of 6d. for each unit (below 65 per cent?).

The base price of 55s. per long ton unit for 65 per cent ore is equivalent to $12.03 per short ton unit, the unit used in the United States. For 60 per cent ore, the standard here, the British price falls to $11.69 a unit in England. In the various camps of Australia the price falls as low as $9.58 per short ton unit for 60 per cent ore.

## BAD CONDITIONS RESULTING FROM PHENOMENAL PRICES.

The great interest in tungsten caused by the unheard-of prices gave promoters of all degrees of honesty a chance to float companies, and the names of engineers of high standing were used in schemes which never had a reasonable basis for being. Companies were organized for millions, and one such company, with only a few questionable claims but with the name of a well-known engineer on its letter head, is said to have actually sold its stock at 50 per cent premium. Other questionable companies, which seemed previously to have about exhausted their list of credulous buyers, were given a new lease on life and took hundreds of thousands of dollars from the gullible part of the public.

As with every high-priced commodity which is easily concealed about the person and for which there is a ready sale, tungsten ores aroused the cupidity of some of the morally weak to the breaking point when rich ore or concentrate reached a price of $2 or $3 a pound. The weak included both workers at the mines and also buyers who deliberately shut their eyes to the origin of the ores and at the same time offered inducements to steal by buying any quantity of ore or concentrates offered—from a pound up. The majority of buyers made such offers honestly, and the nominal purpose of all was to take the ore offered by small producers, to whom it was a great advantage to sell in small lots. At one mine in Arizona it was said that more stolen ore was sold than was obtained by the owner. At Atolia one man was said to operate a mine which produced no ore but gave opportunity to dispose of the ore stolen from a neighboring mine. Petty pilfering at the mills was occasionally planned with some care. The bolder thieves stole concentrates in some places by hundreds of pounds at a time from stock piles or cars.

## GRADE OF CONCENTRATES.

The demand that the tenor of ores be raised to 65 per cent or more of $WO_3$ is in general a careless, wasteful demand, probably founded partly on inexpert metallurgy, partly on the supposition that the miner must foot the bill, and partly on the ground that it is poor

business to transport 40 per cent of inert material when only 35 per cent or less need be carried, and that it costs more to smelt 60 per cent ore than 65 per cent ore. The loss in slimes or fine particles in making 65 per cent concentrates, however, is disproportionately higher than it is in making 60 per cent concentrates on account of having to do more fine grinding or else lose more middling (particles of tungsten minerals with pieces of rock sticking to them), and a very large part of this lost material can never be recovered. Many an operator would receive a shock if he knew exactly the percentage of $WO_3$ in his mill feed and in the tailings.

In the Boulder field it is found advisable by two of the largest companies, the Wolf Tongue Mining Co. and the Vasco Mining Co., to make two products, the higher grade carrying between 50 and 55 per cent of $WO_3$ and the second grade carrying about 20 per cent of $WO_3$. The Primos Mining & Milling Co. concentrates its ores to about 50 per cent of $WO_3$. Each of these companies either reduces its own ore or sells it to a closely related company.

Although some reduction companies still demand higher grades of ore, others are pleased to take all the lower-grade concentrates offered. Naturally, the price paid for the lower-grade ores is less than that for the purer concentrates, but the loss in price amounts to less than the loss of slimes if the low-grade material is reground and reconcentrated.

On account of the physical characteristics of the ore there is, of course, a great difference in the losses in different fields and at different mines in the same field. In general, the finer the particles of the mineral in the ore the more difficult the problem of efficient concentration, and the ores of the Boulder field are among the hardest to handle, though there is a great difference among the ores within the field. The contact metamorphic ores are in general easy to handle, because the scheelite is readily separated from the gangue. Quartz veins holding tungsten minerals in large particles usually present the easier separation problem, but the grade of the ore is usually low.

## WORLD'S PRODUCTION.

Naturally other countries felt the impulse of the boom in tungsten as well as the United States. American and, in less number, English firms sent scouts over that part of the world not controlled by Great Britain to hunt the much wanted ore. From British territory Americans could not draw supplies on account of the embargo on tungsten shipments except to other British possessions.

As stated in former reports, economic conditions have been so disturbed by the European war that it is difficult to obtain figures for the tungsten produced in several countries for years later than 1912. In preparing the following table estimates based on available data have been made for each country. Where authorities are not cited in the notes following the table they have been quoted in preceding years.

*World's production of tungsten ore, 1907–1916, by countries.*

[Estimated as far as possible in short tons of concentrates containing 60 per cent tungsten trioxide.]

| Country. | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|---|---|
| Africa: South Africa | 211 | 40 | 16 | ..... | ..... | ..... | ..... | ..... | 1 | 2 |
| Asia: | | | | | | | | | | |
| Burma and the Shan States | ..... | ..... | ..... | 407 | 1,119 | 2,095 | 1,905 | 2,055 | 3,010 | 4,637 |
| China | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 120 |
| Federated Malay States | 89 | 83 | 99 | 105 | 205 | 275 | 273 | 317 | 353 | 552 |
| French Indo-China (Tonkin) | ..... | ..... | ..... | 19 | ..... | 81 | e100 | 119 | 219 | 164 |
| India (not including Burma) | ..... | ..... | 7 | 23 | ..... | ..... | ..... | ..... | ..... | 100 |
| Japan | 71 | 220 | 292 | 275 | 287 | 225 | 327 | 226 | 478 | 771 |
| Johore and Kedah | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 48 |
| Chosen (Korea) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 74 | 613 |
| Siam | 10 | ..... | ..... | ..... | 200 | 200 | 1 | 33 | 79 | 584 |
| Trengganu (Malay Peninsula) | ..... | ..... | ..... | ..... | ..... | 81 | 101 | 173 | 174 | 329 |
| Australia: | | | | | | | | | | |
| New South Wales | 451 | 269 | 431 | 413 | 512 | 298 | 220 | 244 | 109 | 345 |
| Northern Territory | 177 | 40 | 49 | 78 | 71 | 44 | 42 | 50 | 50 | 45 |
| Queensland | 703 | 516 | 679 | 1,145 | 750 | 944 | 587 | 442 | 708 | 503 |
| South Australia | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1 |
| Tasmania | 46 | 5 | 20 | 75 | 86 | 87 | 89 | 61 | 150 | 124 |
| Victoria | ..... | 3 | 15 | 31 | 33 | 13 | 1 | ..... | ..... | 1 |
| Western Australia | 5 | ..... | 1 | 2 | 12 | ..... | 1 | 1 | ..... | ..... |
| East Indies: | | | | | | | | | | |
| Billiton | 4 | 11 | 12 | 21 | ..... | 21 | 20 | 20 | 20 | 60 |
| Singkep | 1 | 14 | 12 | 12 | ..... | 8 | 10 | 10 | 10 | |
| Europe: | | | | | | | | | | |
| Austria | 50 | 44 | 43 | 54 | 50 | 73 | 57 | 75 | 75 | 150 |
| England | 361 | 261 | 421 | 307 | 298 | 216 | 204 | 230 | 399 | 449 |
| France | 67 | 124 | 55 | 33 | 188 | 252 | 300 | 300 | 300 | 182 |
| Germany (Saxony) | 68 | 46 | 106 | 105 | 89 | 101 | 106 | 119 | 150 | 250 |
| Italy | 18 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 6 |
| Norway | ..... | ..... | ..... | ..... | ..... | 10 | 3 | 4 | e5 | 10 |
| Portugal | 702 | 684 | 609 | 1,132 | 1,078 | 1,466 | 1,246 | 992 | 1,029 | 1,563 |
| Russia | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 11 |
| Spain | 303 | 249 | 142 | 169 | 106 | 202 | 179 | 146 | 215 | 187 |
| Oceania: New Zealand | 153 | 87 | 78 | 187 | 184 | 181 | 297 | 274 | 261 | 322 |
| North America: | | | | | | | | | | |
| Mexico | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 115 | 175 |
| Nova Scotia | ..... | ..... | ..... | 83 | ..... | 17 | 12 | ..... | ..... | ..... |
| United States | 1,640 | 671 | 1,619 | 1,821 | 1,139 | 1,330 | 1,537 | 990 | 2,332 | 5,923 |
| South America: | | | | | | | | | | |
| Argentina | 507 | 548 | 900 | 826 | 683 | 702 | 591 | 482 | 189 | 908 |
| Bolivia | 500 | 187 | 168 | 232 | 370 | 547 | 328 | 320 | 902 | 3,624 |
| Brazil | ..... | 16 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 6 |
| Chile | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 9 |
| Peru | ..... | ..... | ..... | 15 | 57 | 241 | 327 | 130 | 433 | 586 |
| | 6,137 | 4,118 | 5,774 | 7,570 | 7,517 | 9,710 | 8,864 | 7,813 | 11,840 | 23,360 |

*South Africa.*—Bray, J. P. (American consul at Johannesburg), report to the Secretary of State, May 11, 1917. Value of scheelite shipped during 1916, $1,226. The ores are estimated to bring 50 shilling per unit ($10.08 per short ton unit).

*Burma and the Shan States.*—Killick, A. E. H., Note on the mineral production of Burma during the year 1916, pp. 8–9. Rangoon, 1917. Figures as given:

| District. | Output during 1916. | | | Average number of persons employed daily. | | | |
|---|---|---|---|---|---|---|---|
| | Quantity. | | Value. | Men. | Women. | Children. | Total. |
| | *tons. cwt. qr. lb.* | | *Rs.* | | | | |
| Thaton | 91 13 1 14 | | 2,26,181 | 675 | 622 | 88 | 1,385 |
| Tavoy | 3,034 5 2 15 | | 61,58,783 | 8,461 | 253 | 11 | 8,725 |
| Mergui | 339 17 2 12 | | 6,90,204 | 1,075 | 135 | 95 | 1,305 |
| Southern Shan States | 215 0 3 1 | | 2,19,580 | 151 | ..... | ..... | 151 |
| Total, 1916 | 3,679 17 1 14 | | 72,94,748 | 10,362 | 1,010 | 194 | 11,566 |
| Total, 1915 | 2,545 15 3 4 | | 42,65,570 | 5,713 | 459 | 165 | 6,337 |

*China.*—Johnson, N. T. (American consul at Changsha), Production of certain mine products in Hunan in 1916: Report to the Secretary of State, May 11, 1917. The production is that of the Yü-Hau Tungsten Mining Co., at Chunchow, and was made in the second half of 1916. Wolframite. The statistics are said to be incomplete.

*Federated Malay State.*—Senior Warden of Mines, Federated Malay States. Quoted in Min. Jour. (London), vol. 118, p. 422, July 7, 1917. Given as 515 tons [long] of scheelite and wolframite. "The greater quantity was low grade."

*French Indo-China* (Tonkin).—Briggs, L. P. (American consul at Saigon), report to the Secretary of State, July 16, 1917. Gives the following data:

*Tin and tungsten ores production, 1916.*

| Name of mine. | Kilos. | Character of ore. | Value. |
|---|---|---|---|
| Beausite | 89,000 | Mixed, 39 per cent tin, 32 per cent tungsten [$WO_3$]. | $55,970 |
| St. Alexandre | 202,000 | Wolframite, 70 per cent tungsten [$WO_3$] | 228,126 |
| | 33,000 | Cassiterite, 65 per cent tin | |
| | 10,000 | Mixed, 50 per cent wolfram [$WO_3$], 10 per cent tin | |
| Ariane | 24,736 | Mixed, 34 per cent tin, 32 per cent tungsten [$WO_3$]. | 15,247 |
| Ganymede | | | |
| Robert | 50,119 | Mixed, 34 per cent tin, 32 per cent tungsten [estimated as 70 per cent $WO_3$]. | 31,073 |
| Minos | 18,628 | .....do..... | 11,387 |
| Andre | | | |
| Thien Tuc | | | |
| | 432,483 | | 344,698 |

*India (not including Burma).*—Estimated.

*Japan.*—Clements, J. M., statistics obtained from official sources in Japan.

*Johore, Kedah, and Trengganu.*—Gunsaulus, E. N. (American consul at Singapore) report dated July 6, 1917. As given the figures are: Exports from Trengganu, 607,200 pounds, valued at $208,143; Johore, 50,933 pounds, valued at $1,476.28; Kedah, 37,600 pounds (no value). The ore has been considered to carry 65 per cent $WO_3$. Wolframite.

*Chosen (Korea).*—Mining Journal (London), vol. 121, p. 331, June 1, 1918. The production is given as follows, in terms of concentrates between 60 and 70 per cent of $WO_3$: 1915, 61 tons; 1916, 505 tons. The ton is supposed to be the long ton, and $WO_3$ content is taken as 65 per cent.

*Siam.*—Hansen, C. C. (American vice consul, Bangkok), Tin and wolfram in the Siamese Malaya: Letter to the Secretary of State, March 2, 1918. The output formerly all came from the district Nakawon Sritamaraj, but recently tungsten ore has been found farther south. The production in the year ending March 31, 1916, was 7,128 piculs (475 short tons), and in the year ending March 31, 1917, 8,767 piculs (584 short tons). In Commerce Repts. Suppl. No. 58a Hansen says that in 1915–16 (the Siamese year is from April 1 to March 31) 110,000 pounds, valued at $46,330, and in 1916–17 131,040 pounds valued at $69,462, were invoiced through the American consulate for shipment to the United States.

*New South Wales.*—Department of Mines, New South Wales, Ann. Rept., 1916, p. 3, Sydney, 1917. The figures as given are: Scheelite 80.7 long tons, valued at £13,719; wolfram 183.31 long tons, valued at £31,163.

*Northern Territory.*—Sullivan, L. N. (American consul, Newcastle, New South Wales), The production of antimony, bismuth, molybdenum, tin, and tungsten ores in the Northern Territory: Report to the Secretary of State, June 6, 1917. Figures as given: 34 tons, 11 hundredweight, 1 quarter, 24 pounds. Wolframite. Average 69 per cent of $WO_3$. The same information was simultaneously furnished by J. I. Brittain, consul general.

*Queensland.*—Undersecretary for mines, Queensland, Ann. Rept., 1916, p. 30, 1917. As given the figures are: Wolfram 370 long tons, valued at £57,813; mixed bismuth and wolfram 136 long tons 10 hundredweight, valued at £19,069. The bismuth-wolframite concentrates are arbitrarily treated as being half wolframite concentrates, all of which are considered as carrying 70 per cent of $WO_3$.

*South Australia.*—Gee, L. C. E., A review of mining operations in the State of South Australia during the half year ended June 30, 1916, p. 40, Adelaide, 1916. The figures are given as 19 hundredweight of ferberite.

*Tasmania.*—Secretary for mines, Tasmania, Rept., 1916, p. 53. Hobart, 1917. Figures as given: 106,265 [long] tons, valued at £16,910. Considered as carrying 65 per cent of $WO_3$.

*Victoria.*—Secretary for mines, Victoria, Ann. Rept., 1916, p. 6, Melbourne, 1917. "From 15 tons won 12 hundredweight, value £100." Wolframite.

*Western Australia.*—1915: Western Australia Department of Mines, Rept., 1915, p. 12. Wolframite.

*East Indies.*—Based on the English and French estimate of 50 [long] tons. See note under France.

*Austria.*—Estimated.

*England.*—The output of our home mines: Min. Jour. (London), vol. 117, p. 259, May 5, 1917. Advance figures from the Home Office are quoted giving the production for 1916 as 388 tons [long], presumably of about 64 per cent of $WO_3$.

*France.*—The French and English in the proposed allocation of tungsten ores among the allies use "150 tons" as the output of France. This is presumably based on the English standard of long tons and 65 per cent or more of $WO_3$, and would equal 182 or more short tons of concentrates carrying 60 per cent of $WO_3$. Wolframite.

*Germany.*—Estimated.

*Italy.*—The Italian mineral industry in 1916: Min. Jour. (London), vol. 120, p. 148, March 9, 1918. "Associated with the [antimony] deposits in Sardinia, deposits of scheelite were encountered, from which 7½ tonnes of 50 per cent concentrates were obtained."

*Norway.*—Norges Bergverkskrift, 1914, p. 12, Kristiania, 1916, gives the production for 1914 as 4 tonnes of wolframite carrying 60 per cent $WO_3$. The corresponding publications for 1913 and 1912, also on p. 12, give the output as 8 and 10 tons, respectively.

*Portugal.*—Statistics from the Portuguese Department of Mines are quoted by Eng. and Min. Jour. (New York), vol. 105, p. 635, Apr. 6, 1918, as follows: "1915, 860.7 tons; 1916, 1308.5 tons. Exports to the United States: 1915, 83.19 tons; 1916, 94.45 tons. The usual run of ore is 65 per cent." Presumably metric tons are used. Reducing the figures to short tons of 60 per cent $WO_3$ gives 1,563 short tons for 1916, but it is believed by engineers acquainted with tungsten mining in Portugal that enough ore was smuggled out of the country to make the ouput more than 2,000 short tons.

*Russia.*—Tredwell, R. C. (American consul at Petrograd), letter to Secretary of State, December 22, 1917. Figures, obtained from the Russian Bureau of Mining, given for 1916 were: 2,000 poods (72,220 pounds) of concentrates carrying 60 to 65 per cent of $WO_3$.

*Spain.*—1915: Estadística minera de España, Año 1915, p. 40, Madrid, 1917, the figures as given are:

| | Productive mines. | Tonnes. | Mine value. | Value per tonne. | Percentage ($WO_3$). |
|---|---|---|---|---|---|
| | | | *Pesetas.* | *Pesetas.* | |
| Almeria | 1 | 3 | 4,800 | 1,600 | ..... |
| Badajos | 1 | 25 | (a) | ..... | ..... |
| Coruña | ..... | 3.5 | 843 | 241 | 10–15 |
| Orense | 3 | 17 | 20,400 | 1,200 | 50 |
| Pontevedra | 1 | 129.5 | 157,005 | 1,208 | ..... |
| Salamanca | 4 | 39.75 | 33,619 | 848 | 36.60 |
| Zamora | 3 | 293.55 | 6,450 | 22 | 3.4 |
| | | 511.30 | | | |

[a] Not sold.

All the wolframite from Coruña and part of that from Pontevedra is obtained as a by-product from the tin mines.

1916: Palmer, E. E. (American consul at Madrid), report to the Secretary of State, April 23, 1917. Figures as given: Wolfram 454,721 kilograms. Converted to an equivalent of concentrates carrying 60 per cent of $WO_3$ on the basis of the official returns for 1915.

*New Zealand.*—MacDonald, W. D. S. (Minister of Mines, New Zealand). Mines statements for the year 1916, p. 3, Wellington, 1917. The figures given are (exports) 266 [long] tons, valued at £49,070. Supposed to carry about 65 per cent of $WO_3$. Scheelite.

*Mexico.*—The figures given represent the imports into the United States.

*Argentina.*—Figures of exports furnished by the Pan American Bureau. Figures as given: "760,389 kilograms, valued at $1,051,577 gold." Treated as carrying 65 per cent of $WO_3$. Wolframite.

*Bolivia.*—O'Rear, J. D. (American minister, La Paz), report to the Secretary of State, September 1, 1917. The figures as given are: "3035 tons, valued at $2,270,280. The ore is considered as carrying 65 per cent of $WO_3$."

*Brazil.*—Gottschalk, A. M. (American consul general, Rio de Janeiro)., report to the Secretary of State, July 5, 1917. The figures as given are: "99 bags (weighing 5,587 kilograms) of wolframite ore, valued at $4,337." Percentage of $WO_3$ unknown.

*Chile.*—Figures furnished by the Pan American Bureau.

*Peru.*—Jiménez, C. P., Estadística minera en 1916: Cuerpo ing. minas Bol. 86, pp. 141–145, Lima, 1918. 1915: 375 tonnes, 66 per cent of $WO_3$, valued at £70,870; 1916: 523 tonnes, 61 per cent of $WO_3$, valued at £217,783. Huebnerite and wolframite.

## IMPORTS AND EXPORTS.

In 1916, as shown by the figures compiled by the Bureau of Foreign and Domestic Commerce, Department of Commerce, the imports of tungsten-bearing ores for consumption amounted to 4,071 short tons, valued at $7,353,691, against imports in 1915 of 1,534 short tons, valued at $1,044,986. As shown by the entries, the imports in 1916 were as follows:

*Tungsten-bearing ore imported into the United States in 1916, by countries.*

| Country. | Quantity (short tons). | Value. | Country. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| Argentina | 638 | $1,442,569 | Japan | 596 | $1,041,570 |
| Bolivia | 59 | 171,420 | Mexico | 175 | 107,125 |
| Brazil | 6 | 4,031 | Panama | 3 | 7,600 |
| British Guiana | 22 | 44,700 | Peru | 1,126 | 1,475,375 |
| Canada | | 100 | Portugal | 167 | 212,685 |
| Chile | 1,182 | 2,750,364 | Siam | 67 | 57,115 |
| China | 21 | 21,881 | | | |
| France | 2 | 3,494 | | 4,071 | 7,353,691 |
| Hongkong | 7 | 13,662 | | | |

The countries enumerated are not necessarily countries of origin, but merely the countries from which the ore was last billed to the United States in the process of transshipment. Thus the Bolivian ore nearly all went through Peru or Chile and is credited to those countries. But as a matter of fact Bolivia actually shipped to the United States 2,311 tons out of a total export of 3,346 tons;[1] Chile produced only 2.5 tons and Peru only 576 tons (disregarding percentage of $WO_3$). Panama and British Guiana are not known to be producers of tungsten ore. The imported ore came from South America, 3,036 tons; Asia, 691 tons; Mexico, 175 tons; and Europe, 169 tons. The imports of tungsten and ferrotungsten, all from Europe, amounted to 42.6 tons, valued at $157,711; and more than half as much of the same material, 55,125 pounds, valued at $137,812, was taken to Germany by the submarine *Deutschland* on her second trip, in December, 1916.[2]

[1] Official returns through the Pan American Bureau.

[2] See Nickel: U. S. Geol. Survey Mineral Resources, 1916, pt. 2, p. 783, 1919.

## PUBLICATIONS.

The following publications relate to the tungsten deposits of the United States. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Washington, D. C. The other publications listed are not available for distribution by the Survey, but may be consulted at the larger libraries of the country.

### ALASKA.

COLLIER, A. J., The tin deposits of the York region, Alaska: U. S. Geol. Survey Bull. 229, pp. 41, 54–55, 1904. 15c.
The occurrence of wolframite on Tin Creek is mentioned.

JOHNSON, B. L., Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district [Alaska]: U. S. Geol. Survey Bull. 442, pp. 246–260, 1910. 40c.

KNOPF, ADOLPH, Geology of the Seward Peninsula tin deposits [Alaska]: U. S. Geol. Survey Bull. 358, pp. 38, 55–58, 1908. 15c.
Briefly describes the occurrence of wolframite on Tin Creek and of scheelite in contact-metamorphosed limestone on Cape Mountain.

MERTIE, J. B., jr., Lode mining in the Fairbanks district [Alaska]: U. S. Geol. Survey Bull. 662, pp. 418–424, 1916.
Describes replacement scheelite deposits in regionally metamorphosed limestone, probably impure; thin quartz veins carrying scheelite and gold and distributed through several feet of schist, the decay of veins seeming to indicate the decomposition of other minerals; and pegmatite carrying scheelite.

### ARIZONA.

BLAKE, W. P., Hübnerite in Arizona: Am. Ins. Min. Eng. Trans., vol. 28, pp. 543–546, 1899.
Describes the huebnerite deposits at Dragoon, then newly found.

HESS, F. L., Note on a wolframite deposit in the Whetstone Mountains, Ariz.: U. S. Geol. Survey Bull. 380, pp. 164–165, 1909. 40c.
The deposit decribed has peculiar interest to students of ore deposits as it appears to be a segregation from granite like the schlieren of biotite and similar dark minerals at other localities.

——— Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652, 85 pp., 1917.
A general article describing tungsten minerals, accompanying minerals, and characteristics of tungsten deposits with other data on tungsten. Intended to be of service to prospectors and others interested in the subject. The work is illustrated by colored and black and white plates.

HILL, J. M., Note on the occurrence of tungsten minerals near Calabasas, Ariz.: U. S. Geol. Survey Bull. 430, pp. 164–166, 1910. 60c.

RICHARDS, R. W., The Dragoon, Ariz., tungsten deposits: Min. Sci., vol. 57, pp. 93–94, 1908.

RICKARD, FORBES, Notes on tungsten deposits in Arizona: Eng. and Min. Jour., vol. 78, pp. 263–265, 1904.
Describes the huebnerite deposits at Dragoon, Ariz.

SCHRADER, F. C., Mineral deposits of the Santa Rita and Patagonia mountains, Ariz.: U. S. Geol. Survey Bull. 582, pp. 353–355, 1915. 50c.
Practically a reprint of the article by Hill in Bull. 430.

### CALIFORNIA.

HESS, F. L., Note on a tungsten-bearing vein near Raymond, Cal.: U. S. Geol. Survey Bull. 340, p. 271, 1908. 30c.
The deposit has no economic value.

KNOPF, ADOLPH, Tungsten deposits of northwestern Inyo County, Cal.: U. S. Geol. Survey Bull. 640, pp. 229–249, 1917.
Describes the contact-metamorphic deposits carrying scheelite, near Bishop, Cal.

STORMS, W. H., New scheelite discovery: Min. and Sci. Press, vol. 113, p. 768, 1916.
Describes contact-metamorphic scheelite prospects on the western side of Greenhorn Mountains, Kern County, Cal., near the head of Cedar Creek canyon and 2 miles south on Slick Rock Creek near the road between Glenville and Kernville, at an altitude of about 6,500 feet.

SUER, GORDON, A new tungsten find: Am. Min. Rev., vol. 23, p. 9, Mar. 7, 1908.
Describes a huebnerite deposit 7 or 8 miles east of Vontrigger near Goffs, San Bernardino County, Cal.

——— Tungsten at Victorville: Am. Min. Rev., vol. 24, pp. 8–9, July 11, 1908.
Describes an economically unimportant contact-metamorphic tungsten deposit. One of the first descriptions of such deposits in this country.

## COLORADO.

BASTIN, E. S., and HILL, J. M., Preliminary report on the economic geology of Gilpin County, Colo.: U. S. Geol. Survey Bull. 620, pp. 295–323 [tungsten ores, p. 311], 1916. 30c.
Gives very brief mention of the ferberite deposits of Boulder County, Colo.

FITCH, R. S., and LAUGHLIN, G. F., Wolframite and scheelite at Leadville, Colo.: Econ. Geology, vol. 11, pp. 30–36, 1916.

GEORGE, R. D., and CRAWFORD, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., 1908, pp. 7–103, 1909.
Describes the ferberite deposits of Boulder County, Colo.

HESS, F. L., and SCHALLER, W. T., Colorado ferberite and the wolframite series: U. S. Geol. Survey Bull. 583, 75 pp., 1914. 20c.
A study of the mineralogy of the ferberite of Colorado and the related tungsten minerals huebnerite and wolframite.

LINDGREN, WALDEMAR, Some gold and tungsten deposits of Boulder County, Colo.: Econ. Geology, vol. 2, pp. 453–463, 1907.

MCKENNA, R. C., Mining tungsten ores in Colorado: Iron Trade Rev., Dec. 30, pp. 1280–1282, 1915.

PROSSER, W. C., Tungsten in San Juan County, Colo.: Eng. and Min. Jour., vol. 90, p. 320, 1 fig., Aug. 13, 1910.
Describes the occurrence of huebnerite near Silverton.

## CONNECTICUT.

HOBBS, W. H., The old tungsten mine at Trumbull, Conn.: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pp. 7–22, 1901. $2.25.

——— Tungsten mining at Trumbull, Conn.: U. S. Geol. Survey Bull. 213, p. 98, 1903. Exhausted.

## IDAHO.

AUERBACH, H. S., Tungsten-ore deposits of the Coeur d'Alene: Eng. and Min. Jour., vol. 86, pp. 1146–1148, 6 figs., 1908.
Describes scheelite deposits near Murray, Idaho.

UMPLEBY, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 73–74, 77, 79, 109–112, 1913. 40c.
Describes briefly the occurrence of huebnerite on Patterson Creek, Lemhi County, Idaho.

## MISSOURI.

HAWORTH, ERASMUS, A contribution to the Archaean geology of Missouri.: Am. Geologist, vol. 1, pp. 294–295, 1888.
Gives a brief description of the wolframite deposit at Silvermine, Mo.

## MONTANA.

WINCHELL, ALEXANDER N., Notes on tungsten minerals from Montana: Econ. Geology, vol. 5, pp. 158–165, 3 figs., 1910.
Describes briefly the scheelite deposits at Jardine and the huebnerite at the Birdie and Scottish Chief mines at Butte.

WINCHELL, A. N., Mining districts of the Dillon quadrangle, Mont., and adjacent areas: U. S. Geol. Survey Bull. 574, p. 125, 1914. 20c.
Describes the quartz veins near Pony, Mont., which carry huebnerite and grade into pegmatite.

NEVADA.

HILL, J. M., Notes on some mining districts in eastern Nevada: U. S. Geol. Survey Bull. 648, pp. 38, 41, 42, 62–63, 206–207, 1916. 30c.
Describes contact-metamorphic deposits carrying scheelite in the Ruby Range near Ruby Valley post office, Elko County (pp. 62–63), and the huebnerite deposits at Tungstonia in the Regan district, in the Kern Mountains, White Pine County (pp. 206–207).
SMITH, F. D., The Osceola, Nev., tungsten deposits: Eng. and Min. Jour., vol. 73, pp. 304–305, 1902.
Describes the huebnerite deposits 12 miles south of Osceola, Nev.
WEEKS, F. B., An occurrence of tungsten ore in eastern Nevada: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 6, pp. 319–320, 1901. $1.
Describes the huebnerite deposits 12 miles south of Osceola, Nev.
——— Tungsten ore in eastern Nevada: U. S. Geol. Survey Bull. 213, p. 103, 1903. Exhausted.
Practically the same article concerning the huebnerite deposits 12 miles south of Osceola, Nev., as that in the Twenty-first Ann. Rept.
——— Tungsten deposits in the Snake Range, White Pine County, eastern Nevada: U. S. Geol. Survey Bull. 340, pp. 263–270, 1908. 30c.
Further data concerning the Osceola deposits obtained at a later visit to them.

SOUTH DAKOTA.

HESS, F. L., Tin, tungsten, and tantalum deposits of South Dakota: U. S. Geol. Survey Bull. 380, pp. 131–163 [tungsten, 149–157], 1909. 40c.
Describes tungsten deposits near Hill City and Lead, S. Dak.
IRVING, J. D., Some recently exploited deposits of wolframite in the Black Hills of South Dakota: Am. Inst. Min. Eng. Trans., vol. 31, pp. 683–695, 1902.
Describes the general geology and occurrence of wolframite in the vicinity of the Homestake, Wasp No. 2, and other gold mines near Lead, S. Dak.
——— Economic resources of the Northern Black Hills: U. S. Geol. Survey, Prof. Paper 26, pp. 163–169, 1905. 55c.
Contains about the same article as the publication referred to above.
O'HARRA, CLEOPHAS, Mineral wealth of the Black Hills, S. Dak.: South Dakota Geol. Survey Bull. 3, pp. 67–72, 1902.

WASHINGTON.

BANCROFT, HOWLAND, Notes on tungsten deposits near Deer Park, Wash.: U. S. Geol. Survey Bull. 430, pp. 214–216, 1910. 60c.
——— The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 29, 111–123, 130–133, 1914. 20c.
Describes tungsten deposits in Cedar County and Deer Park areas, Stevens County, Wash.

GENERAL.

HESS, F. L., Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652, 85 pp., 25 pls., 4 figs., 1917.
A general description of tungsten minerals, their mode of occurrence, and accompanying minerals. Ten plates are colored in an effort to show tungsten minerals in natural colors.

# RADIUM, URANIUM, AND VANADIUM.

By FRANK L. HESS.

## INTRODUCTION.

The output of uranium and vanadium ores in 1916 amounted to about 20,300 tons containing 10 grams of radium (Ra), 33.7 tons of uranium (77,600 pounds of $U_3O_8$), and 460 tons of vanadium. Any value given to the output must be arbitrary and open to question, for the larger part of the uranium ores was produced by companies that themselves used the ores and the vanadium ore was produced wholly by the Primos Chemical Co., which also reduced the ore. Although there is a market for carnotite ore ($K_2O.2UO_3.V_2O_5+8H_2O$), which gives a basis for estimating the value of other similar ores, there is none for vanadium ore. The approximate value, as ore, was probably about $500,000.

The output for 1916 may be compared with that for 1915, which was 47,000 tons of ore containing 6.1 grams of radium, 19.9 tons of uranium (46,872 pounds of $U_3O_8$), and 627 tons of vanadium. The estimate given in the report for 1915 included an arbitrary estimate of the value of vanadium concentrates; the value as ore would be very much less.

## AREAS OF PRODUCTION.

As heretofore, much the largest supply of uranium ores came from the carnotite fields of Montrose County, mostly around and near Paradox Valley, and near Gateway, Mesa County, in southwestern Colorado. A smaller quantity came from the San Rafael Swell, Emery County, and La Sal Mountains, San Juan and Grand counties, in southeastern Utah.

During 1916 the National Radium Institute took from the Colorado-Gilpin Gold & Uranium Co. 112 tons of low-grade pitchblende ore, 6 tons of higher-grade ore, and 900 pounds of choice ore, which it concentrated and treated for radium contained. The ores had been mined for some years, the greater part from the German-Belcher mine and the remainder from the Woods mine, near Central City, Gilpin County, Colo. The institute finished its work with the treatment of the pitchblende and the concentrated carnotite ores, and it was thought at the end of the year that the plant would probably be taken over by the Pittsburgh Radium Co., which had carnotite claims on Yellow Cat Wash, southeast of Thompsons, Grant County, Utah.

The only vanadium ore mined as such in this country was the roscoelite-bearing sandstone worked by the Primos Chemical Co. at Placerville, Sawpit, and Vanadium, San Miguel County, Colo. A

larger quantity of vanadium is imported by the American Vanadium Co. from its mine at Minasragra, Peru, where the ore occurs as patronite (the sulphide) and the oxidation products of patronite.

## USES, DEMAND, AND TRADE.

The demand for radium had a considerable setback after the United States entered the war but soon increased greatly, though the purposes for which it was to be used were those with the minimum permanent value. The greatest demand for radium in 1916 was for use in the illumination of watch faces. Many thousands of the cheapest watches, the life of which is ordinarily not more than two or three years, were thus equipped, and oddly enough the illumination of the more expensive watches has followed much more slowly. Gun sights, compass faces, and airplane dials of various kinds were also illuminated. From those articles the radium is not recoverable. Mesothorium would do as well as radium or even better, and the radium might have been saved for therapeutic uses. Radium attains its full strength as an excitant for illumination in about a month, but mesothorium requires between four and five years to attain its full strength, though it reaches a usable strength in a year or less.

When used as an illuminant a radium salt is mixed with artificial zinc sulphide and a cementing material, such as amyl acetate ("banana oil"). The alpha rays (helium atoms) given off by the radium strike the particles of zinc sulphide and make them luminescent. The degree of luminescence depends on the quality of the zinc suphide and on the quantity of radium present. Pure radium salts are not luminous in the dark, though the commercial salts always glow from the impurities present.

Radium has proved itself so valuable in the treatment of human disease in ways for which no acceptable substitute is known that every effort should be made to conserve it. The half-life of mesothorium is only 5.5 years, but that of radium is estimated at 1,760 to 2,000 years, so that, even were mesothorium otherwise equally desirable, it is not to be considered as an investment by hospitals and surgeons in comparison with radium, unless furnished at a small fraction of the cost, and at present that can not be done.

Experienced surgeons say that if radium were useful for nothing else, the relief from pain it gives in certain forms of cancer makes it worth its whole cost. Radium cures some tumors which before it was discovered were successfully treated only by severe operations, and it is otherwise so useful that it can not well be dispensed with. That it does not cure all cancers or all other tumors is beside the mark. Its value is sufficiently proved without claiming for it universal application. Outside of necessary war uses, such as marking gun sights, airplane dials, compasses for ships, chronometers, and a few watches, the use of radium should be prohibited except for therapeutic purposes, and when its use for other purposes is allowed, the allowance should be only for the weakest mixtures that will do the work.

Monazite, a thorium-bearing mineral, is imported in large quantity from Brazil for making gas mantles, of which thoria (thorium

oxide) is the principal incandescent constituent. Mesothorium could be obtained from this source, and its substitution for radium on all watch, clock, and similar dials, push buttons, numbers, and other objects to be illuminated should be made compulsory, so that radium, which is insufficient in quantity at best, may be saved for higher use.

The wisdom of the movement that was started several years ago for the withdrawal from entry of lands that are possibly radium bearing becomes more and more apparent. The fields have been broadened very little, but the uses for radium have enlarged greatly.

A patent (U. S. patent No. 1202625) was issued to Charles Viol and assigned to the Standard Chemical Co. for baking a mixture of radioactive and radiosensitive materials in an enamel for watch and clock faces.

The uses for uranium have not grown much. Many attempts have been made to use uranium in steel either as a substitute for tungsten or otherwise, and in this work the Standard Chemical Co., as the largest producer of uranium ore, has taken an energetic part. Various formulas for high-speed steels containing uranium have been proposed. One steel was manufactured with the composition given below:

*Formula for uranium-bearing high-speed tool steel.*

| | |
|---|---|
| Carbon (C) | 0.65 |
| Vanadium (V) | 1.00 |
| Tungsten (W) | 8.00–12.00 |
| Chromium (Cr) | 4.00 |
| Molybdenum (Mo) | 3.00 |
| Uranium (U) | 3.00 |
| Iron (Fe) | 80.00–83.00 |

The principal use of vanadium is still in steels, especially where resistance to repeated strains is desired and in tool steels.

## PRICES.

The price of radium was from $90 to $120 a milligram for the element contained in a salt, such as the chloride or bromide, in a material containing 50 per cent or more of the pure salt.

Prices for carnotite were nominal and a subject of individual bargaining but ran about $2 a pound for the $U_3O_8$, in ore carrying 2 per cent of $U_3O_8$, with a bonus for richer ore and a penalty for lower grades. Uranium in ferrouranium, carrying 30 to 40 per cent of uranium, was quoted at $7.50 a pound.

Vanadium in ferrovanadium, carrying 35 to 50 per cent of vanadium, was sold for $1.80 to $2.50 a pound.

# ZINC.

(GENERAL REPORT.)

By C. E. SIEBENTHAL.

## SUMMARY.

*Spelter produced and consumed in the United States, 1910–1916, in short tons.*

| | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| Production of primary spelter: [a] | | | | | | | |
| From domestic ore | 252,479 | 271,621 | 323,907 | 337,252 | 343,418 | 458,135 | 563,451 |
| From foreign ore | 16,705 | 14,905 | 14,899 | 9,424 | 9,631 | 31,384 | 104,005 |
| | 269,184 | 286,526 | 338,806 | 346,676 | 353,049 | 489,519 | 667,456 |
| Production of secondary spelter: [a] | | | | | | | |
| Redistilled | 12,784 | 14,043 | 26,064 | 25,991 | 20,545 | 29,764 | 29,663 |
| Remelted | 28,439 | 26,470 | 26,187 | 24,014 | 22,424 | 23,136 | 21,037 |
| | 310,407 | 327,039 | 391,057 | 396,681 | 396,018 | 542,419 | 718,156 |
| Apparent consumption of primary spelter | 245,884 | 280,059 | 340,341 | 295,370 | 299,125 | 364,632 | 458,428 |

[a] "Primary spelter," which is produced directly from ore, is here distinguished from "secondary spelter," which is obtained by refining zinc ashes, skimmings, drosses, and old metals. The statistics of secondary spelter are given on page 813. Wherever in this report the word "spelter" is used without qualification it means primary spelter.

The production of primary spelter from domestic ores in 1916 was 563,451 short tons, valued at $151,005,000, based on the average selling price, as compared with 458,135 short tons, valued at $113,617,000, based on the average selling price, in 1915—an increase of 105,316 tons, or about 23 per cent, in quantity and of $37,388,000, or about 33 per cent, in value.

## INTRODUCTION.

Though the publication of this report has been so greatly delayed by the press of work growing out of the war that it has value only as a statistical record, the essential figures have been available since the beginning of 1917.

A statement of the production and consumption of spelter during the first six months of 1916 was published August 15, 1916. A preliminary estimate of the production of primary spelter in 1916, based on reports received from every zinc smelter in operation, giving the actual production for the first 11 months of 1916 and estimates for the remainder of the year, was issued in the form of a press bulletin on January 3, 1917. A statement giving the final figures of production and consumption of spelter in 1916 was published April 9, 1917. This statement gave a list of smelters and

electrolytic zinc plants brought up to date, a list of the new plants under construction and contemplated, tables showing exports of zinc and manufacture of zinc by months and tables showing imports of zinc ore and exports of spelter by countries, and set forth the results of the stimulus of the war on the zinc industry of the United States by six-month periods. It also gave a chart showing the range through 1914–1916 of the weekly average price of spelter at St. Louis and London and of the weekly average price of 60 per cent concentrates and the weekly sales of concentrates in the Joplin region.

The statistics of production in this country have been compiled by the United States Geological Survey from confidential reports from each zinc-smelting company in operation during 1916. Statistics of the recovery of secondary zinc were collected from all the important secondary smelters and refiners. The statistics of domestic consumption are taken in part from the smelter returns and in part from the records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, and the tables for foreign production and consumption were compiled from the sources indicated.

## PRODUCTION.

### ANNUAL PRODUCTION, 1873–1916.

The production of spelter in the United States began in an experimental way in 1858,[1] and regular production began in 1860 at the Lehigh Zinc Works in the East and at the Matthiesson & Hegeler works in the West. Between 1864 and 1870 nine or ten other zinc smelters were established. Statistics of production are recorded for the years 1873 and 1875 and for the census year ending May 31, 1880. Annual statistics have been collected by the United States Geological Survey since 1882. The progress of the zinc-smelting industry since 1873 is shown in the following table:

*Spelter produced in the United States from domestic and foreign ores, 1873–1916, in short tons.*

| Year. | From foreign ore. | From domestic ore. | Total. | Year. | From foreign ore. | From domestic ore. | Total. |
|---|---|---|---|---|---|---|---|
| 1873 | ..... | 7,343 | 7,343 | 1898 | ..... | 115,399 | 115,399 |
| 1875 | ..... | 15,833 | 15,833 | 1899 | ..... | 129,051 | 129,051 |
| 1880 (census year) | ..... | 23,239 | 23,239 | 1900 | ..... | 123,886 | 123,886 |
| 1882 | ..... | 33,765 | 33,765 | 1901 | ..... | 140,822 | 140,822 |
| 1883 | ..... | 36,872 | 36,872 | 1902 | ..... | 156,927 | 156,927 |
| 1884 | ..... | 38,544 | 38,544 | 1903 | ..... | 159,219 | 159,219 |
| 1885 | ..... | 40,688 | 40,688 | 1904 | ..... | [a] 186,702 | 186,702 |
| 1886 | ..... | 42,641 | 42,641 | 1905 | ..... | [a] 203,849 | 203,849 |
| 1887 | ..... | 50,340 | 50,340 | 1906 | 25,076 | 199,694 | 224,770 |
| 1888 | ..... | 55,903 | 55,903 | 1907 | 26,115 | 223,745 | 249,860 |
| 1889 | ..... | 58,860 | 58,860 | 1908 | 19,675 | 190,749 | 210,424 |
| 1890 | ..... | 63,683 | 63,683 | 1909 | 25,535 | 230,225 | 255,760 |
| 1891 | ..... | 80,873 | 80,873 | 1910 | 16,705 | 252,479 | 269,184 |
| 1892 | ..... | 87,260 | 87,260 | 1911 | 14,905 | 271,621 | 286,526 |
| 1893 | ..... | 78,832 | 78,832 | 1912 | 14,899 | 323,907 | 338,806 |
| 1894 | ..... | 75,328 | 75,328 | 1913 | 9,424 | 337,252 | 346,676 |
| 1895 | ..... | 89,686 | 89,686 | 1914 | 9,631 | 343,418 | 353,049 |
| 1896 | ..... | 81,499 | 81,499 | 1915 | 31,384 | 458,135 | 489,519 |
| 1897 | ..... | 99,980 | 99,980 | 1916 | 104,005 | 563,451 | 667,456 |

[a] Including an unknown quantity smelted from foreign ore, small in 1904, but larger in 1905.

[1] Ingalls, W. R., Lead and zinc in the United States, p. 314, 1908.

*Spelter produced in the United States, 1906–1916, apportioned according to States in which it was smelted, in short tons.*

| Year. | Eastern and Southern States. | Illinois. | Missouri. | Kansas. | Oklahoma. | Colorado. | Total. |
|---|---|---|---|---|---|---|---|
| 1906 | 29,930 | 47,939 | 11,077 | 129,564 | ..... | 6,260 | 224,770 |
| 1907 | 37,626 | 56,056 | 11,732 | 134,108 | 5,035 | 5,303 | 249,860 |
| 1908 | 32,738 | 50,244 | 10,201 | 99,298 | 14,864 | 3,079 | 210,424 |
| 1909 | 42,941 | 67,653 | 7,037 | 103,299 | 28,782 | 6,048 | 255,760 |
| 1910 | 43,606 | 73,038 | 5,571 | 105,697 | 34,760 | 6,512 | 269,184 |
| 1911 | 47,155 | 83,130 | 4,116 | 98,443 | 46,315 | 7,397 | 286,526 |
| 1912 | 56,252 | 88,397 | 7,085 | 101,104 | 76,925 | 9,043 | 338,806 |
| 1913 | 69,063 | 106,654 | 5,085 | 74,106 | 83,214 | 8,554 | 346,676 |
| 1914 | 77,593 | 127,946 | 3,550 | 44,510 | 91,367 | 8,083 | 353,049 |
| 1915 | 103,409 | 159,958 | 6,754 | 101,423 | 109,208 | 8,767 | 489,519 |
| 1916 | 159,387 | 181,433 | 8,317 | 141,286 | 168,206 | 8,827 | 667,456 |

## ZINC DUST.

Zinc dust has been marketed by domestic smelters since 1910. The United States Zinc Co., at Pueblo, Colo., was the first to prepare it for the market; the Grasselli Chemical Co. followed later; and one by one other companies began to save zinc dust, until in 1916 the companies named below reported production. Some of these companies saved zinc dust for the first time in 1914, 1915, or 1916, from the incentive supplied by the high price of zinc dust consequent upon the inability of Belgium and Germany to export any to the United States.

American Zinc & Chemical Co., Langeloth, Pa.
Anaconda Copper Mining Co., Great Falls, Mont.
Clarksburg Zinc Co., Clarksburg, W. Va.
Grasselli Chemical Co., Clarksburg, W. Va.
Illinois Zinc Co., Peru, Ill.
Mineral Point Zinc Co., Depue, Ill.
National Zinc Co., Bartlesville, Okla., and Springfield, Ill.
New Jersey Zinc Co., Palmerton, Pa.
United States Smelting Co., Altoona, Kans.
United States Zinc Co., Pueblo, Colo.

The following table gives the output of zinc dust since its first production in a commercial way in the United States:

*Production of zinc dust in the United States, 1910–1916.*

| | Short tons. | | Short tons. |
|---|---|---|---|
| 1910 | 69 | 1914 | 1,004 |
| 1911 | 254 | 1915 | 1,755 |
| 1912 | 492 | 1916 | 2,609 |
| 1913 | 423 | | |

As will be seen from the table of imports of zinc dust given on page 823, the imports fell off about two-thirds in 1915 and were still smaller in 1916, on account of the increased domestic production.

## ZINC PIGMENTS.

Zinc forms the base, either in whole or in part, of four white pigments—zinc oxide, leaded zinc oxide, zinc-lead oxide, and lithopone. All of these may be and in the United States the first three usually have been made directly from zinc ore. No zinc-lead oxide has been made since 1909, when the plant at Canon City, Colo., was closed. The output of zinc oxide and leaded zinc oxide may not be disclosed, as it was confined to one large producer and one or two smaller ones.

Lithopone is an intimate mixture by chemical precipitation of zinc sulphide and barium sulphate. It may be manufactured from ore, spelter, or zinc oxide, but in the United States it is generally made from zinc skimmings, zinc ashes, and scrap zinc. The production of lithopone is growing rapidly, as is shown in the following table. The figures for 1906–1914 inclusive represent marketed product and those for subsequent years give the total quantity produced.

*Lithopone produced in the United States, 1906–1916, in short tons.*

| | | | |
|---|---|---|---|
| 1906 | 4,300 | 1912 | 24,220 |
| 1907 | 10,275 | 1913 | 29,685 |
| 1908 | 8,292 | 1914 | 32,819 |
| 1909 | 14,847 | 1915 | 43,422 |
| 1910 | 12,655 | 1916 | 57,960 |
| 1911 | 16,866 | | |

The zinc content of the various pigments made in the United States from ore, both domestic and foreign, for the period 1908–1916, is given in the table below. On page 813 a portion of the secondary zinc recovered in the form of pigments is given.

*Primary zinc content of zinc pigments made in the United States, 1908–1916, in short tons.*

| | | | |
|---|---|---|---|
| 1908 | 48,004 | 1913 | 70,622 |
| 1909 | 54,139 | 1914 | 70,619 |
| 1910 | 50,592 | 1915 | 79,572 |
| 1911 | 46,122 | 1916 | 90,276 |
| 1912 | 64,032 | | |

## SECONDARY ZINC.

By the ordinary method of galvanizing, in which the material to be coated is dipped into a bath of molten zinc, there is a great loss of zinc in the form of semioxidized skimmings and of hard zinc drosses, consisting of the alloy formed by the zinc with the iron of the tank and the iron of the article that is being galvanized. The larger galvanizing plants have furnaces to resmelt these skimmings and drosses and to recover the spelter. There are also many small plants and some large ones which make a practice of buying galvanizer's skimmings and drosses and of recovering the spelter. A considerable quantity of old metal in the form of various alloys of zinc with copper and other metals is also worked over and brought up to the desired composition by the addition of new metal. At almost every brass foundry and machine shop in the country it is the custom to remelt and use brass filings, grindings, and scrap copper and brass, and it is manifestly impracticable to attempt to take full account of such material. Some of the zinc smelters running on ore find it advantageous to work in a quantity of secondary material, because the loss of zinc in distillation is practically a fixed quantity per charge, whether the charge is of low or high tenor. If secondary material high in zinc is mixed with low-grade ore, the loss per unit of metal recovered is thereby greatly lessened. Where this is done the smelters make proper returns to the United States Geological Survey, and in these reports prior to 1907 account has been taken of such production, the output being recorded as dross or secondary spelter. As such spelter has been recovered by redistillation, it is practically indistinguishable in quality from spelter of ordinary grades made from ore. Several secondary smelters recover zinc from drosses by redistillation,

and these plants are included in the list of smelters on a later page. In the table below the secondary spelter recovered by redistillation is separated from that recovered by remelting. The canvass of secondary smelters was made by J. P. Dunlop, of the United States Geological Survey.

*Secondary zinc produced in the United States, 1911–1916, in short tons.*

| | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| Secondary spelter, redistilled | 14,043 | 26,064 | 25,991 | 20,545 | 29,764 | 29,663 |
| Secondary spelter, remelted | 26,470 | 26,187 | 24,014 | 22,424 | 23,136 | 21,037 |
| Recovered zinc in alloys, excluding old brass remelted | 3,223 | 3,912 | 3,743 | 3,914 | 5,300 | 2,600 |
| Recovered zinc in remelted brass | 24,110 | 28,426 | 25,822 | 24,759 | 34,375 | 61,700 |
| Secondary zinc recovered as metal | 67,846 | 84,589 | 79,570 | 71,642 | 92,575 | 115,000 |
| Secondary zinc recovered in pigment | 3,036 | 4,619 | 3,705 | 6,536 | 8,323 | 8,749 |
| Secondary zinc recovered in zinc chlorides[a] | 3,865 | 4,903 | 6,253 | 6,429 | 7,860 | 6,319 |
| Total secondary zinc | 74,747 | 94,111 | 89,528 | 84,607 | 108,758 | 130,000 |

[a] These figures include only the quantity of zinc chloride used in wood preservation and were furnished by courtesy of the Forest Service, Department of Agriculture.

## COMPARISON OF TOTALS BASED ON SMELTER AND MINE REPORTS.

The figures of the production of spelter given in the foregoing pages are compiled from reports from individual zinc smelters. Since 1904 statistics of the production of the more valuable metals in the Western States have been obtained by the United States Geological Survey from reports of individual mines, and since 1907 this compilation has been extended over the whole country. In order to put the smelter production on the same basis as the mine figures, all the zinc which is manufactured into pigments directly from ore (exclusive of the quantity in zinc oxide manufactured from spelter, the inclusion of which would entail its duplication in the totals) is added to the production of metallic zinc. The zinc dust recovered during the year is also included here. The zinc recovered from secondary sources is excluded, for it has already been once reckoned as spelter. These facts must be borne in mind in comparing the subjoined table with the table showing the production of spelter.

*Comparison of production of domestic zinc by smelters and by mines, 1907–1916, in short tons.*

| | Totals compiled from smelter reports. | Totals compiled from mine reports. | Smelter excess. | Mine excess. |
|---|---|---|---|---|
| 1907 | 280,676 | 259,951 | 20,725 | ..... |
| 1908 | 238,030 | 234,526 | 3,504 | ..... |
| 1909 | 283,173 | 305,423 | ..... | 22,250 |
| 1910 | 303,139 | 327,712 | ..... | 24,573 |
| 1911 | 315,029 | 345,260 | ..... | 30,231 |
| 1912 | 386,783 | 378,816 | 7,967 | ..... |
| 1913 | 408,289 | 406,416 | 1,873 | ..... |
| 1914 | 424,672 | 406,959 | 17,713 | ..... |
| 1915 | 539,074 | 586,491 | ..... | 47,417 |
| 1916 | 656,075 | 701,995 | ..... | 45,920 |
| | 3,834,940 | 3,953,549 | ..... | 118,609 |

The smelter totals represent actual recovery and are found by summing up the total production reported by all companies and calculating all pigments and zinc dust back to equivalent metallic zinc on the basis of average analysis of product. In compiling the mine totals each producing operator is requested to report actual quantity of zinc ores and concentrates shipped, and from these returns the zinc content is reckoned by assay value. From that zinc content 10 to 20 per cent, according to the character of the ore, is deducted for smelting losses, and the sum of the remainders thus obtained from all the producing properties in each State gives the total for the State. Where the ore is concentrated at a custom mill, proper allowance is also made for the loss of metal in the process. It is clear that by either method the correctness of the totals is dependent upon complete and correct returns from each producing mine and smelter. It is further essential to the correctness of the mine totals that the assay content and the theoretical recovery be correctly estimated. The totals, as compiled from smelter reports and from mine reports, respectively, should be in reasonable agreement. As a matter of fact, for any year they show considerable divergence. These discrepancies, giving rise to "smelter excess" or "mine excess," may be the result of one cause or of a combination of causes, among which are lag in the smelting of the ore, resulting in accumulation of ore stocks at the smelters; lag in the mining, owing to which the smelter depletes its ore stocks; error in calculating metallic content from assay and in estimating recovery.

The smelter reports give the exact annual production of zinc and serve as a check on the mine production, and they also give the form in which the zinc was recovered, whether as spelter or as pigment. For more exact statements of distribution of zinc production according to origin, recourse must be had to the reports of production by mines.

## MINE PRODUCTION.

*Mine production of zinc in the United States, 1907–1916, in short tons.*

| | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|---|---|
| Arizona | 114 | 339 | 2,989 | 2,742 | 2,281 | 4,379 | 4,714 | 4,896 | 9,110 | 9,839 |
| Arkansas | 474 | 605 | 510 | 994 | 664 | 748 | 478 | 608 | 3,209 | 6,815 |
| California | 116 | ..... | ..... | ..... | 1,404 | 2,173 | 529 | 195 | 6,547 | 7,628 |
| Colorado | 26,394 | 15,065 | 25,605 | 38,545 | 47,304 | 66,111 | 59,673 | 48,387 | 52,297 | 67,143 |
| Idaho | 3,493 | 19 | 676 | 2,802 | 4,170 | 6,953 | 11,587 | 21,006 | 35,077 | 43,253 |
| Illinois | 737 | 1,717 | 2,163 | 3,549 | 4,219 | 4,065 | 2,236 | 4,811 | 5,534 | 3,404 |
| Iowa | 145 | 395 | 35 | 96 | ..... | ..... | ..... | ..... | ..... | 21 |
| Kansas | 17,772 | 14,119 | 11,445 | 13,229 | 10,272 | 10,633 | 10,088 | 11,284 | 14,365 | 12,448 |
| Kentucky | ..... | ..... | 56 | 6 | 158 | 491 | 327 | 230 | 764 | 1,096 |
| Missouri | 116,752 | 107,404 | 130,162 | 128,589 | 122,515 | 136,551 | 124,963 | 105,994 | 136,300 | 155,960 |
| Montana | 122 | 820 | 4,680 | 15,819 | 21,905 | 13,459 | 44,337 | 55,790 | 93,573 | 114,630 |
| Nevada | 1,084 | 558 | 1,507 | 1,354 | 1,774 | 6,661 | 7,210 | 6,490 | 12,188 | 16,222 |
| New Hampshire | ..... | ..... | ..... | ..... | ..... | ..... | 15 | 6 | 24 | 36 |
| New Jersey | 69,369 | 67,165 | 82,510 | 68,678 | 77,445 | 69,755 | 72,156 | 74,253 | 116,618 | 110,698 |
| New Mexico | 375 | 1,788 | 6,543 | 9,044 | 5,119 | 6,783 | 8,262 | 9,202 | 12,702 | 18,285 |
| New York | ..... | ..... | ..... | ..... | 81 | ..... | ..... | ..... | 2,455 | 4,507 |
| North Carolina | ..... | ..... | ..... | ..... | ..... | 142 | 10 | ..... | ..... | ..... |
| Oklahoma | 1,657 | 4,529 | 7,806 | 6,394 | 5,150 | 5,769 | 11,664 | 13,992 | 14,314 | 28,754 |
| Tennessee | 109 | 344 | 596 | 966 | 1,117 | 2,191 | 5,583 | 10,425 | 16,461 | 26,428 |
| Texas | 22 | 18 | ..... | ..... | ..... | 119 | 326 | 108 | 15 | 116 |
| Utah | 2,726 | 730 | 4,930 | 8,184 | 8,920 | 8,534 | 9,429 | 7,995 | 12,146 | 14,786 |
| Virginia | ..... | 705 | 58 | 794 | 1,032 | 249 | 2,719 | 174 | 1,267 | 2,276 |
| Washington | ..... | ..... | ..... | ..... | 10 | ..... | ..... | ..... | 122 | 847 |
| Wisconsin | 18,490 | 18,206 | 23,152 | 25,927 | 29,720 | 33,050 | 30,110 | 31,113 | 41,403 | 56,803 |
| | 259,951 | 234,526 | 305,423 | 327,712 | 345,260 | 378,816 | 406,416 | 406,959 | 586,491 | 701,995 |

The following table shows, for each zinc-producing State, the total quantity of zinc ore produced and the output of each kind of zinc ore. The column headed "All other ore" includes lead ore, copper ore, copper-lead ore, and dry or siliceous ore, no zinc of consequence being recovered from any of them except in California, Colorado, and Montana. "Dry" ores produced in Colorado in 1916 contained 3,700 short tons of recoverable zinc. Copper-zinc ores produced in California contained 4,104 tons of recoverable zinc, and similar ores produced in Montana contained 1,932 tons of recoverable zinc. These ores, however, were concentrated from parts of the ore from certain counties and were not distributed through the whole of the "All other ore" credited to those States in 1916. The total crude ore yielding either gold, silver, copper, lead, or zinc is given for each zinc-producing State, so that a comparison may be made of the relative extent of deep mining operations for all five metals in these States, the quantity of crude ore raised being the best measure for this purpose. The table discloses the fact that Missouri produced between one-fourth and one-fifth of the crude-ore output of the zinc-producing States, her production being 18,664,024 short tons of crude ore, of which 13,196,400 tons was zinc bearing. Exclusive of iron ore, this was the largest production of metalliferous crude ore in the United States. Next in rank was Arizona, with 17,033,810 tons of crude copper ore; Utah ranked third, with 13,920,643 tons of crude ore. Michigan, which formerly ranked second in quantity of crude ore raised, was fourth in 1916, with 12,364,114 tons.

The table gives also the quantity of recoverable zinc contained in the crude ores of each State and the quantity of zinc recovered from each kind of zinc ore. The percentage of recoverable zinc contained in the zinc ore and the zinc-lead ore of each State is also shown. The recoverable zinc content of crude zinc ore ranged from 35 per cent for a small quantity produced in Washington down to 1.1 per cent in Missouri; the Western States show uniformily the higher percentages. The average recoverable zinc content of the zinc ore of the United States in 1916 was 2.4 per cent, as against 2.7 per cent in 1915. Of the total mine production of zinc in 1916, a quantity corresponding to 73.3 per cent was derived from zinc ore, 25 per cent from zinc-lead ore, and 1.5 per cent from all other ores. The figures of mine production of zinc are taken from the chapters on gold, silver, copper, lead, and zinc (mine production) in the various States, as indicated in the prefatory note.

*Mine production of zinc in the United States in 1916.*

| State. | Zinc ore. | | | Zinc-lead ore. | | | All other ore (short tons). | | Total. (short tons). | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Crude ore (short tons). | Recoverable zinc content. | | Crude ore (short tons). | Recoverable zinc content. | | Crude ore. | Recoverable zinc content. | Crude ore. | Recoverable zinc content. |
| | | Quantity (short tons). | Percentage. | | Quantity (short tons). | Percentage. | | | | |
| Arizona | 52,659 | 5,154 | 9.8 | 55,956 | 3,972 | 7.1 | 16,925,195 | 713 | 17,033,810 | 9,839 |
| Arkansas | 249,000 | 6,815 | 2.7 | | | | | | 249,000 | 6,815 |
| California | 29,079 | 3,485 | 12.0 | 1,816 | 39 | 2.2 | 3,156,747 | 4,104 | 3,187,642 | 7,628 |
| Colorado | 151,497 | 26,437 | 17.4 | 291,489 | 37,006 | 12.7 | 2,254,257 | 3,700 | 2,697,243 | 67,143 |
| Idaho | 23,158 | 5,651 | 25.3 | 1,136,553 | 37,602 | 3.3 | 1,558,334 | | 2,718,045 | 43,253 |
| Illinois | [a] 288,100 | 3,404 | 1.4 | | | | | | [a] 288,100 | 3,404 |
| Iowa | [b] 1,000 | 21 | 2.1 | | | | | | [b] 1,000 | 21 |
| Kansas | 774,400 | 12,448 | 1.8 | | | | | | 774,400 | 12,448 |
| Kentucky | [b] 11,000 | 1,096 | 10.0 | | | | | | [a] 11,000 | 1,096 |
| Missouri | 13,196,400 | 155,960 | 1.1 | | | | 5,467,624 | | 18,664,024 | 155,960 |
| Montana | 388,380 | 33,254 | 8.6 | 702,885 | 79,444 | 11.3 | 6,769,160 | 1,932 | 7,860,425 | 114,630 |
| Nevada | 31,886 | 9,945 | 31.2 | 33,303 | 6,277 | 18.8 | 5,875,976 | | 5,941,165 | 16,222 |
| New Hampshire | | | | 3,500 | 36 | 10.2 | | | 3,500 | 36 |
| New Jersey | 712,464 | 110,698 | 15.5 | | | | | | 712,464 | 110,698 |
| New Mexico | [c] 137,696 | 18,285 | 13.3 | | | | 3,733,254 | | 3,870,950 | 18,285 |
| New York | 40,800 | 4,507 | 11.0 | | | | | | 40,800 | 4,507 |
| Oklahoma | 1,406,900 | 28,754 | 2.0 | | | | | | 1,406,900 | 28,754 |
| Tennessee | 702,326 | 26,428 | 3.7 | | | | 482,495 | | 1,184,821 | 26,428 |
| Texas | 443 | 116 | 26.2 | | | | 52,589 | | 53,032 | 116 |
| Utah | 18,400 | 4,433 | 24.1 | 461,866 | 10,353 | 2.2 | 13,440,377 | | 13,920,643 | 14,786 |
| Virginia | 4,480 | 959 | 21.4 | 30,961 | 1,317 | 4.2 | 3,821 | | 39,262 | 2,276 |
| Washington | 154 | 54 | 35.0 | 17,039 | 793 | 4.6 | 147,805 | | 164,998 | 847 |
| Wisconsin | 3,066,500 | 56,803 | 2.3 | | | | | | 3,066,500 | 56,803 |
| | 21,286,722 | 514,707 | 2.4 | 2,735,368 | 176,839 | 6.5 | 59,867,634 | 10,449 | 83,889,724 | 701,995 |
| Percentage of total recoverable zinc derived from each kind of ore | | 73.3 | | | 25.0 | | | 1.5 | | 100.0 |

[a] Exclusive of fluorspar ore. [b] Estimate. [c] Includes zinc-lead ore.

## ZINC-REDUCTION PLANTS.

### ELECTROLYTIC ZINC PLANTS.

*Electrolytic zinc plants in the United States at the end of 1916.*

| Company. | Location of plant. | Daily spelter capacity. | Remarks. |
|---|---|---|---|
| American Smelting & Refining Co. | Murray, Utah | Experimental | Operated in 1916. |
| Anaconda Copper Mining Co. | Anaconda, Mont. | 25 tons | Operated in 1915–16. |
| Do | Great Falls, Mont. | 200 tons | Under construction; 100 tons in operation at end of 1916. |
| Basin Salvage Co | Basin, Mont | Experimental | Under construction. |
| Bully Hill Copper Co | Bully Hill, Calif | do | Operated in 1915–16. |
| Electrolytic Zinc Co | Baltimore, Md | 10 tons | Operated in 1916. |
| Judge Mining & Smelting Co. | Park City, Utah | 15 tons | Completed March, 1917. |
| Mammoth Copper Mining Co. | Kennett, Calif | 25 tons | To be completed by May, 1917. |
| Reed Zinc Co | Palo Alto, Calif | Experimental | Operated in 1914–15; idle in 1916. |
| River Smelting & Refining Co. | Keokuk, Iowa | 10 tons | Operated in 1916. |

The rated capacity of the plants listed above was about 40,000 tons annually, but that capacity was attained only near the end of the year. The rated capacity on the completion of plants then under construction was expected to be about 85,000 tons. The output of electrolytic spelter in 1916 was 12,916 tons, of which 1,800 tons was refined from prime western spelter, 887 tons from scrap and drosses, and 10,229 tons from ore.

## ZINC SMELTERS.

The following table gives the zinc-smelting capacity of the United States on December 31, 1915 and June 30 and December 31, 1916, as well as the retorts under construction or contemplated at the end of the year. The plants marked "A" operate sulphuric-acid plants, either at the smelter or elsewhere, as indicated in the footnotes.

*Zinc smelters in the United States, 1915 and 1916.*

| | Location of works. | Retorts at end of 1915. | Retorts June 30, 1916. | Retorts at end of 1916. | Additional retorts contemplated or under construction. |
|---|---|---|---|---|---|
| ARKANSAS. | | | | | |
| Arkansas Zinc & Smelting Corporation | Van Buren | ..... | 2,400 | 3,200 | ..... |
| Athletic Mining & Smelting Co | Fort Smith | ..... | ..... | ..... | 2,400 |
| Fort Smith Spelter Co | ....do | ..... | 2,560 | 2,560 | ..... |
| | | ..... | 4,960 | 5,760 | 2,400 |
| COLORADO. | | | | | |
| United States Zinc Co | Pueblo | 2,208 | 1,944 | 1,984 | 264 |
| ILLINOIS. | | | | | |
| American Zinc Co. of Illinois (A) | Hillsboro | 4,000 | 4,864 | 4,864 | ..... |
| Collinsville Zinc Smelter | Collinsville | 1,792 | 2,304 | 2,304 | ..... |
| Granby Mining & Smelting Co. (A) | East St. Louis | 3,220 | 3,220 | 4,820 | 800 |
| Hegeler Zinc Co. (A) | Danville | 3,600 | 5,400 | 5,400 | ..... |
| Illinois Zinc Co. (A) | Peru | 4,640 | 4,640 | 4,640 | 800 |
| Matthiesson & Hegeler Zinc Co. (A) | La Salle | 6,168 | 6,168 | 6,168 | ..... |
| Missouri Zinc Co | Beckemeyer | 352 | 352 | 352 | ..... |
| Mineral Point Zinc Co. (A)[a] | Depue | 9,068 | 9,068 | 9,068 | ..... |
| National Zinc Co. (A)[b] | Springfield | 3,200 | 4,480 | 4,480 | ..... |
| Robert Lanyon Zinc & Acid Co. (A) | Hillsboro | 1,840 | 3,200 | 3,200 | ..... |
| Sandoval Zinc Co | Sandoval | 672 | 672 | 672 | 672 |
| | | 38,552 | 44,368 | 45,968 | 2,272 |
| KANSAS. | | | | | |
| American Spelter Co | Pittsburg | 896 | 992 | 992 | ..... |
| American Zinc, Lead & Smelting Co | Caney | 6,080 | 6,080 | 6,080 | ..... |
| Do | Dearing | 4,480 | 4,480 | 4,480 | ..... |
| Chanute Spelter Co | Chanute | 1,280 | 1,280 | 1,280 | ..... |
| Cherokee Smelting Co | Bruce | 896 | 896 | 896 | ..... |
| Edgar Zinc Co | Cherryvale | 4,800 | 4,800 | 4,800 | 240 |
| Granby Mining & Smelting Co | Neodesha | 3,760 | 3,760 | 3,760 | ..... |
| Iola Zinc Co | Concreto | 660 | 1,320 | 1,320 | ..... |
| Joplin Ore & Spelter Corporation | Pittsburg | 1,444 | 1,792 | 1,792 | ..... |
| Lanyon Smelting Co | ....do | 448 | 448 | 448 | ..... |
| Owen Zinc Co | Caney | 1,280 | 1,280 | 1,920 | ..... |
| Pittsburg Zinc Co | Pittsburg | 910 | 910 | 910 | ..... |
| Prime Western Spelter Co. (A)[c] | Gas | 4,868 | 4,868 | 4,868 | ..... |
| United States Smelting Co | Altoona | 3,960 | 4,600 | 4,600 | ..... |
| Do | Iola | 3,440 | 3,440 | 3,440 | ..... |
| Do | La Harpe | 1,924 | 1,924 | 1,926 | ..... |
| Weir Smelting Co | Weir | ..... | ..... | 288 | ..... |
| | | 41,126 | 42,870 | 43,800 | 240 |

[a] The Mineral Point Zinc Co. also operates an acid plant at Mineral Point, Wis.
[b] The National Zinc Co. has zinc-roasting furnaces at Argentine, Kans., where the sulphur gases are utilized in an acid plant, the roasted concentrates being shipped to the smelter at Springfield, Ill.
[c] The Prime Western Spelter Co. has roasting furnaces and an acid plant at Tiltonville, Ohio.

*Zinc smelters in the United States, 1915 and 1916*—Continued.

| | Location of works. | Retorts at end of 1915. | Retorts June 30, 1916. | Retorts at close of 1916. | Additional retorts contemplated or under construction. |
|---|---|---|---|---|---|
| MISSOURI. | | | | | |
| Edgar Zinc Co. | St. Louis | 2,000 | 2,000 | 2,000 | ..... |
| Missouri Zinc Smelting Co. | Rich Hill | ..... | 448 | 448 | ..... |
| Nevada Smelting Co. | Nevada | 672 | 672 | 672 | ..... |
| | | 2,672 | 3,120 | 3,120 | ..... |
| OKLAHOMA. | | | | | |
| Bartlesville Zinc Co. | Bartlesville | 5,184 | 6,336 | 6,336 | ..... |
| Do. | Blackwell | ..... | 1,600 | 9,600 | ..... |
| Do. | Collinsville | 10,752 | 13,440 | 13,440 | ..... |
| Bartlesville Zinc Co. (Lanyon-Starr plant). | Bartlesville | 3,456 | 3,456 | 3,456 | ..... |
| Eagle-Picher Lead Co. | Henryetta | ..... | ..... | 4,000 | ..... |
| Henryetta Spelter Co. | do | ..... | 3,000 | 3,000 | ..... |
| Kusa Spelter Co. | Kusa | 3,720 | 7,720 | 7,720 | ..... |
| National Zinc Co. | Bartlesville | 4,970 | 4,970 | 4,970 | ..... |
| Oklahoma Spelter Co. | Kusa | ..... | 1,600 | 1,600 | ..... |
| Quinton Spelter Co. | Quinton | ..... | ..... | 1,344 | 1,344 |
| Tulsa Fuel & Manufacturing Co. | Collinsville | 6,232 | 6,232 | 6,232 | ..... |
| United States Smelting Co. | Checotah | ..... | 2,560 | 5,120 | ..... |
| United States Zinc Co. | Sand Springs | 5,680 | 8,000 | 8,000 | 200 |
| Western Spelter Co. | Henryetta | ..... | ..... | 2,400 | ..... |
| | | 39,994 | 58,914 | 77,218 | 1,544 |
| PENNSYLVANIA. | | | | | |
| American Steel & Wire Co. (A) | Donora | 3,648 | 9,120 | 9,120 | ..... |
| American Zinc & Chemical Co. (A) | Langeloth | 3,648 | 6,384 | 7,296 | ..... |
| New Jersey Zinc Co. (of Pennsylvania) | Palmerton | 6,720 | 6,960 | 7,200 | ..... |
| | | 14,016 | 22,464 | 23,616 | ..... |
| WEST VIRGINIA. | | | | | |
| Clarksburg Zinc Co. | Clarksburg | 3,648 | 3,648 | 3,648 | ..... |
| Grasselli Chemical Co. (A)[a] | do | 5,760 | 5,760 | 5,760 | ..... |
| Do. | Meadowbrook | 8,592 | 8,592 | 8,544 | ..... |
| United Zinc Smelting Corporation (A). | Moundsville | ..... | ..... | ..... | 6,912 |
| | | 18,000 | 18,000 | 17,952 | 6,912 |
| | | 156,568 | 196,640 | 219,418 | 13,632 |
| PLANTS WITH SPECIAL RETORTS.[b] | | | | | |
| Eastern Zinc Refining Co. | Brooklyn, N. Y. | ..... | ..... | 8 | 16 |
| John Finn Metal Works | San Francisco, Calif. | ..... | ..... | 2 | 1 |
| Michael Hayman & Co. | Buffalo, N. Y. | 12 | 12 | 12 | ..... |
| M. M. S. Metal Co. | Trenton, N. J. | ..... | 21 | 21 | ..... |
| Trenton Smelting & Refining Co. | do | 96 | 96 | 96 | ..... |
| William Cramp & Sons Ship & Engine Building Co. | Philadelphia, Pa. | 32 | 32 | 32 | ..... |
| Total large retorts | ..... | 140 | 161 | 171 | 17 |

[a] The Grasselli Chemical Co. operates acid plants in connection with its zinc-roasting furnaces at Grasselli, Ind., Cleveland, Canton, and Lockland (near Cincinnati), Ohio, and Newcastle, Pa., the roasted zinc concentrates being shipped to the smelters at Clarksburg and Meadowbrook, W. Va.

[b] Large graphite retorts yielding 600–800 pounds of spelter per charge.

The foregoing list includes a few retort smelters that treat only secondary materials, such as zinc ashes, skimmings, and galvanizers' drosses; also a few that recover about equal quantities of spelter from ores and from secondary materials, as well as several more that treat minor quantities of secondary materials. Several other zinc-smelting plants in the country obtain spelter by the distillation

of zinc ashes and drosses in large graphite crucibles and condensers somewhat similar to those used in the Faber du Faur furnaces for recovering zinc from the zinc crusts in lead desilverization. These are given at the bottom of the list.

### INCREASE IN SMELTING CAPACITY.

The number of retorts at zinc smelters at the end of 1915 was 156,568, and 49,612 additional retorts were being built or were planned, making a total of 206,180. The number of smelters June 30, 1916, was 196,640, and 24,812 additional retorts were being built or were planned, making a total of 221,452. At the end of 1916 the total number of retorts was 219,418, and 13,632 additional retorts were under construction or planned.

The heavy decline in the price of spelter during May, June, and July caused the temporary closing of some of the smaller smelters and the reduction of operation by several others. A canvass by the Survey showed nearly 19,000 idle retorts out of a total of 199,328. Some of the active retorts, however, were being used to treat secondary materials, such as zinc ashes and drosses, and an unknown number of others were engaged in refining the ordinary grade of spelter by redistillation. The number of retorts on August 15 was somewhat larger than that on June 30, owing to the completion of some of those under construction at the earlier date. Between July and December there was a considerable improvement in the price of spelter, and the year ended with fewer retorts idle, the number being about 15,000.

### SMELTER CHANGES IN 1916.

Some of the smelters listed as planned early in the year were abandoned, and some other plants never got beyond the promotion stage. On the other hand, work was begun on three smelters not listed. Extensive additions were made to plants already in existence.

In Pennsylvania the plant of the Donora Zinc Co. was completed and put into full operation, and the plant of the American Zinc & Chemical Co. was increased to double its former capacity.

In West Virginia the United Zinc Smelting Corporation, affiliated with the Clarksburg Zinc Co., broke ground at Moundsville in July for a smelter of 6,912 retorts and an acid plant.

In Illinois additional capacity was installed at Hillsboro (by the American Zinc Co. of Illinois and the Robert Lanyon Zinc & Acid Co.), at Collinsville, at Danville, and at Springfield. The Granby Mining & Smelting Co. made an addition of 1,600 retorts at East St. Louis, and a block of retorts was under construction December 31 at East St. Louis and at Peru.

In Missouri the old coal-fired smelter at Rich Hill was rebuilt by the Missouri Zinc Smelting Co.

In Kansas another block of 660 retorts was erected by the Iola Zinc Co. at Concreto. Additions were made by the Joplin Ore & Spelter Corporation at Pittsburg, by the Owen Zinc Co. at Caney, and by the United States Smelting Co. at Altoona. At Weir City, the site of the first zinc smelter west of St. Louis, the Weir Smelting Co. built a small coal-fired smelter.

In Oklahoma the Bartlesville Zinc Co. erected a smelter of 9,600 retorts at Blackwell. At Henryetta the Henryetta Spelter Co. completed a 3,000-retort smelter and the Eagle-Picher Lead Co. one of 4,000 retorts. At Kusa the La Harpe Spelter Co. built a plant of 4,000 retorts, which was absorbed by the Kusa Spelter Co., and the Oklahoma Spelter Co. built a plant of 1,600 retorts. The Quinton Spelter Co. erected 1,340 retorts at Quinton, and the J. B. Kirk Gas Smelting Co. built a plant with 2,560 retorts at Checotah. On August 15 the United States Smelting Co. traded its plant at Iola Kans., for the plant at Checotah and doubled its capacity. The United States Zinc Co. added 2,320 retorts at Sand Springs, and the Bartlesville Zinc Co. added 1,152 retorts at Bartlesville and 2,688 at Collinsville, making the Collinsville smelter, with 13,440 retorts, by far the largest zinc smelter in the world.

In Arkansas the Fort Smith Spelter Co. built a smelter with 2,560 retorts at Fort Smith, and the Arkansas Zinc & Smelting Corporation erected a plant of 2,400 retorts at Van Buren. The Athletic Mining & Smelting Co. began the construction of a plant of 2,400 retorts. All these plants draw natural gas from pools in the vicinity of Fort Smith.

The American Zinc, Lead & Smelting Co. took over the Granby Mining & Smelting Co., acquiring mining lands and a lead smelter in Missouri, a natural-gas zinc smelter at Neodesha, Kans., and the new smelter at East St. Louis. For a time at least the corporate identity of the Granby Co. will be preserved.

## TRADE CONDITIONS.

### WORLD'S PRODUCTION.

Owing to the disturbed conditions in Europe, complete figures of the world's production of spelter in 1914–1916 can not be given. In the subjoined table the fragmentary statistics for those years were obtained from consular reports, official reports, mining journals, or any other source available.

The following spelter statistics prior to 1914, apportioned according to the country where the ore was smelted and not according to the source of the ore, are the figures of Henry R. Merton & Co., of London, taken from the annual statistical publication for 1913 of the Metallgesellschaft, the Metallurgische Gesellschaft, A.-G., and the Berg und Metallbank Aktiengesellschaft of Frankfort on the Main, Germany, except that the figures for the United States are those of the United States Geological Survey:

*World's production of spelter, 1910–1916, in short tons.*

| Country. | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| Australia | 560 | 1,904 | 2,531 | 4,105 | 5,616 | 5,300 | 5,700 |
| Austria | 14,666 | 18,602 | 21,609 | 23,928 | ..... | ..... | ..... |
| Belgium | 190,233 | 215,050 | 220,678 | 217,928 | ..... | ..... | ..... |
| Canada | ..... | ..... | ..... | ..... | ..... | ..... | [a] 2,974 |
| France | [b] 54,456 | [b] 63,810 | [b] 71,969 | [b] 71,672 | ..... | ..... | ..... |
| Germany | 251,046 | 276,008 | 298,794 | 312,075 | ..... | ..... | ..... |
| Great Britain | 69,531 | 73,806 | 63,086 | 65,197 | [c] 56,000 | [c] 50,000 | [c] 67,000 |
| Holland | 23,121 | 25,059 | 26,380 | 26,811 | 18,098 | 12,243 | ..... |
| Japan | ..... | ..... | ..... | ..... | 6,554 | 23,421 | 42,899 |
| Norway | ..... | 7,363 | 8,959 | 10,237 | [c] 21,000 | [c] 28,000 | [c] 36,000 |
| Russia | 9,514 | 10,952 | 9,659 | 8,389 | 6,900 | 2,300 | 1,400 |
| Spain | 10,735 | 6,981 | 7,874 | 6,617 | 12,944 | 8,497 | 9,395 |
| Sweden | ..... | ..... | ..... | ..... | 2,535 | 9,466 | 11,020 |
| United States | 269,184 | 286,526 | 338,806 | 346,676 | 353,049 | 489,519 | 667,456 |
| | 893,046 | 986,061 | 1,070,045 | 1,093,635 | ..... | ..... | ..... |
| United States percentage of world's production | 30.1 | 29.1 | 31.7 | 31.7 | ..... | ..... | ..... |

[a] Mineral production of Canada, 1917, Canada Dept. Mines, 1919.
[b] Obtained by subtracting Spanish production from Metallgesellschaft total for France and Spain.
[c] Quin's Metal Handbook and Statistics.

## IMPORTS AND EXPORTS.

The following tables of imports and exports of zinc and of zinc remaining in warehouse are made up from the publications and records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce.

### WAREHOUSE TRANSACTIONS.

Zinc imported into the United States as metal or in ore may be entered for immediate consumption, in which case the duty is paid and the zinc goes direct to the importer; or it may be entered for warehouse, bond being given for double the amount of the estimated duty. In accordance with the usage of the Bureau of Foreign Commerce, the term "General imports" in the accompanying tables indicates the total zinc imports, including both zinc articles entered for immediate consumption on arrival and zinc articles entered for warehouse, as distinguished from "Imports for consumption," embracing zinc imports entered for immediate consumption and zinc withdrawals from warehouse for consumption. The statement of general imports and the statement of imports for consumption for any period will differ to the extent that the entries for warehouse for the period differ from withdrawals from warehouse for consumption.

From warehouse the zinc ore may be withdrawn for consumption by payment of duty, or it may be exported from warehouse as ore, or it may be smelted in bond, the metal finally being either withdrawn for consumption or exported from warehouse with cancellation of bond. In the table of imports for consumption the imports are expressed in the terms under which they were originally entered. The zinc imported for consumption may be actually used in the country or it may be manufactured and exported, in which case the manufactuer is entitled to the benefit of a drawback of 99 per cent of the duties paid. In the table showing foreign zinc exported in manufactures with benefit of drawback the zinc is shown in the form in which it

was originally imported, because, on account of diversity of manufactured form, it is not feasible to show the articles actually exported. The foreign zinc given in the table below as exported from warehouse is likewise shown in the form in which it was imported and entered for warehouse. Foreign zinc exported from warehouse has, since July 1, 1915, been included by the Bureau of Foreign and Domestic Commerce in the domestic exports as "from foreign ore."

The items foreign zinc exported from warehouse, domestic exports of zinc "from foreign ore," and foreign zinc exported in manufactures with benefit of drawback make up the total foreign zinc going out of the country. For the sake of simplicity this foreign zinc is carried on the records of the bonded customs warehouse in the form in which the zinc was entered until the bond is canceled. It must be clearly understood, therefore, that the zinc listed in the table of foreign exports of zinc, on a later page, was not exported as zinc content of ore but as spelter smelted from the ore. This has been shown in the Monthly Summary of the Bureau of Foreign and Domestic Commerce since July, 1915, as noted above.

No record is kept of the zinc in the form in which it is actually exported, except for that portion of the articles manufactured from foreign zinc and exported with benefit of drawback. For articles not wholly made of zinc it would be useless to give weights; but each shipment on which drawback is claimed is accompanied by a manifest of the imported zinc used in making the articles and the duty paid thereon. From these manifests is derived the statement of the total quantity of foreign zinc used in manufactures exported with the benefit of drawback. For this reason the zinc is given in the form in which it was imported.

### ZINC REMAINING IN WAREHOUSE.

The following table is taken from the reports of the Bureau of Foreign and Domestic Commerce. For the reasons already given the zinc is shown in the terms in which it was imported. For instance, a considerable part of the zinc stated as remaining in ore doubtless represents spelter waiting at the bonded zinc smelter for a favorable market for shipment. If this is borne in mind the table gives an idea of the fluctuation of stocks of foreign zinc.

The quantity of zinc remaining in warehouse at the end of each year prior to 1909 has been negligible, but since all zinc ore became dutiable, on August 6, 1909, the quantity of bonded zinc has largely increased. The large imports of foreign zinc on account of the demand for munitions greatly swelled the quantity remaining in warehouse December 31, 1915 and 1916, as will be seen in the accompanying tables.

Practically all the zinc in ore remaining in warehouse prior to 1915 was credited to the port of Kansas City, Mo., and was in possession of the bonded zinc smelters of Kansas and Oklahoma. In 1915 and 1916 eastern zinc smelters were important consumers of foreign ores, and at the end of these years considerable ore remained in warehouse in that section.

*Zinc remaining in warehouse in the United States Dec. 31, 1909–1916.*

| Year. | Ore and calamine. | | | Blocks, pigs, and old. | | Zinc dust.[a] | |
|---|---|---|---|---|---|---|---|
| | Quantity (short tons). | Zinc content (pounds). | Value. | Quantity (pounds). | Value. | Quantity (pounds). | Value. |
| 1909 | 2,813 | 2,255,341 | $36,384 | 78,667 | $4,021 | ..... | ..... |
| 1910 | 2,603 | 2,572,122 | 61,730 | 61,146 | 3,406 | ..... | ..... |
| 1911 | 10,177 | 6,978,098 | 137,055 | 63,454 | 4,049 | ..... | ..... |
| 1912 | 3,076 | 2,479,565 | 62,089 | ..... | ..... | 310,715 | $18,072 |
| 1913 | 7,531 | 1,930,425 | 68,726 | ..... | ..... | 291,612 | 16,008 |
| 1914 | 6,728 | 6,987,676 | 90,257 | 221,994 | 11,100 | 272,915 | 13,005 |
| 1915 | 63,168 | 43,691,611 | 1,628,509 | 63,892 | 4,028 | 115,375 | 8,815 |
| 1916 | 82,227 | 57,259,940 | 2,210,286 | 180,026 | 14,301 | 120,921 | 12,989 |

[a] Not separately recorded prior to 1912.

The figures for 1910–1912 are exclusive of the zinc contained in certain other ores entered at New York, as explained later in the discussion of the table of general imports of zinc.

## IMPORTS.

*Zinc imported and entered for consumption in the United States, 1902–1916.*

| Year. | Blocks or pigs. | | Sheets. | | Old. | | Value of manufactures. | Total value. |
|---|---|---|---|---|---|---|---|---|
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | | |
| 1902 | 448 | $36,536 | 68 | $8,339 | 157 | $8,299 | $32,708 | $85,882 |
| 1903 | 202 | 19,161 | 129 | 8,537 | 163 | 11,772 | 10,376 | 49,846 |
| 1904 | 341 | 34,211 | 17 | 2,230 | 36 | 3,247 | 10,394 | 50,082 |
| 1905 | 428 | 46,295 | 14 | 1,953 | 86 | 5,110 | 8,253 | 61,611 |
| 1906 | 1,021 | 240,632 | 22 | 3,236 | 79 | 7,647 | 2,904 | 254,419 |
| 1907 | 1,709 | 220,474 | 52 | 7,158 | 122 | 8,582 | 8,516 | 244,730 |
| 1908 | 776 | 78,160 | 37 | 4,570 | 37 | 2,014 | 5,645 | 90,389 |
| 1909 | 9,419 | 805,087 | 117 | 13,510 | 238 | 9,999 | 6,488 | 835,084 |
| 1910 | 989 | 95,410 | 262 | 36,641 | 257 | 17,549 | 1,526 | 151,126 |
| 1911 | 323 | 38,322 | 296 | 55,211 | 104 | 8,609 | 7,961 | 110,123 |
| 1912 | 10,719 | 1,239,574 | 728 | 102,073 | 147 | 13,748 | 8,489 | 1,363,884 |
| 1913 | 5,165 | 565,215 | 223 | 43,497 | 275 | 17,850 | 5,474 | 632,036 |
| 1914 | 195 | 21,140 | 277 | 32,004 | 388 | 26,512 | 4,464 | 84,120 |
| 1915 | 63 | 16,864 | 95 | 14,407 | 729 | 103,294 | 622 | 134,565 |
| 1916 | 21 | 4,436 | 2 | 432 | 642 | 112,254 | 829 | 117,951 |

*Zinc dust, zinc oxide, and lithopone imported and entered for consumption in the United States, 1910–1916.*

| Year. | Zinc dust. | | Zinc oxide. | | | | Lithopone. | |
|---|---|---|---|---|---|---|---|---|
| | | | Dry. | | In oil. | | | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. |
| 1910 | 1,493 | $136,749 | 3,069 | $365,701 | 197 | $30,874 | 1,863 | $99,954 |
| 1911 | 1,713 | 177,420 | 2,506 | 316,972 | 274 | 40,494 | 3,178 | 166,199 |
| 1912 | 2,736 | 306,061 | 2,675 | 342,965 | 262 | 43,168 | 2,952 | 153,303 |
| 1913 | 2,368 | 248,482 | 3,291 | 410,493 | 142 | 23,663 | 2,533 | 152,980 |
| 1914 | 2,004 | 191,582 | 2,461 | 279,642 | 168 | 43,196 | 4,036 | 277,822 |
| 1915 | 707 | 137,474 | 853 | 148,220 | 29 | 5,929 | 2,126 | 144,567 |
| 1916 | 522 | 230,380 | 447 | 181,319 | 18 | 4,076 | 2,372 | 414,592 |

*General imports of old brass fit only for remanufacture, 1903–1916.*

[Average composition about one-third zinc and two-thirds copper.]

| Year. | Quantity (short tons). | Value. | Year. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| 1903 | 608 | $154,260 | 1910 | 3,072 | $786,684 |
| 1904 | 1,330 | 310,311 | 1911 | 1,803 | 445,116 |
| 1905 | 4,838 | 1,169,320 | 1912 | 3,298 | 639,045 |
| 1906 | 6,469 | 1,891,126 | 1913 | 4,363 | 907,521 |
| 1907 | 3,979 | 1,344,753 | 1914 | 2,565 | 487,542 |
| 1908 | 1,357 | 355,335 | 1915 | 8,354 | 1,809,550 |
| 1909 | 2,336 | 579,454 | 1916 | 22,976 | 6,578,809 |

Two tables which show the importation of zinc ores are given below. The first one shows the zinc ores imported and entered for consumption under the tariff act of 1909, when different grades of ore bore different duties, and also shows the imports under the tariff act of 1913, which levies an ad valorem duty, thus making one class of all grades of zinc ore. The other table shows the general imports of zinc by countries. The difference between general imports and imports for consumption has been explained on page 821.

*Zinc ore and calamine imported and entered for consumption, 1909–1916.*

| Year. | Containing less than 10 per cent of zinc (duty free). | | Containing from 10 to 20 per cent of zinc (duty, ½ cent per pound). | | Containing from 20 to 25 per cent of zinc (duty, ½ cent per pound). | | Containing 25 per cent or more of zinc (duty, 1 cent per pound).[a] | |
|---|---|---|---|---|---|---|---|---|
| | Zinc content (short tons). | Value. | Zinc content (short tons). | Value. | Zinc content (short tons). | Value. | Zinc content (short tons). | Value. |
| 1909[b] | ..... | ..... | 167 | $8,690 | 113 | $5,632 | 4,695 | $161,430 |
| 1910 | 16 | $698 | 87 | 4,053 | 1,178 | 25,127 | 19,961 | 713,684 |
| 1911 | 39 | 1,411 | 189 | 8,705 | 564 | 16,914 | 3,349 | 120,756 |
| 1912 | 22 | 1,141 | 56 | 3,045 | 458 | 6,734 | 10,328 | 433,570 |
| 1913 | ..... | ..... | [b] 45 | 2,067 | [c] 309 | 4,395 | 4,093 | 193,014 |
| 1914 | ..... | ..... | ..... | ..... | ..... | ..... | 5,548 | 149,503 |
| 1915 | ..... | ..... | ..... | ..... | ..... | ..... | 16,282 | 1,312,833 |
| 1916 | ..... | ..... | ..... | ..... | ..... | ..... | 55,796 | 3,836,414 |

[a] Includes all classes after Oct. 4, 1913.
[b] For period July 1–Dec. 31 only.
[c] For period Jan. 1–Oct. 3, 1913; Oct. 4–Dec. 31, included in class "containing 25 per cent or more of zinc."

The statistics of general imports as published by the Bureau of Foreign and Domestic Commerce are based on "consular invoice" or "declaration," which is only a close approximation to actual weights and values. The true weights and values of all dutiable articles are determined when the duties are paid, and the correction is applied as "additions by liquidation" or "deductions by liquidation." On free articles this correction is not made. Prior to 1909 zinc ore was in large part undutiable, and in that part of 1909 prior to August 6 a portion of the imports of zinc ore was free. The correction by liquidation for the dutiable zinc ore imported during 1909–1912 is available, but, owing to special instructions followed in one customs district, to apply the correction by liquidation would result in a considerable duplication of imports. The following figures are taken

directly from the Monthly Summary of the Bureau of Foreign and Domestic Commerce without the liquidation correction:

*General imports of zinc ore into the United States, 1904–1916.*

1904–1912.

| Year. | Canada. | | Mexico. | | Total. | |
|---|---|---|---|---|---|---|
| | Ore (short tons). | Zinc content (short tons). | Ore (short tons). | Zinc content (short tons). | Ore (short tons). | Zinc content (short tons). |
| 1904 | ..... | ..... | 2,264 | ..... | 2,264 | ..... |
| 1905 | 4,063 | ..... | 18,074 | ..... | 22,137 | ..... |
| 1906 | 423 | ..... | 59,991 | ..... | 55,414 | ..... |
| 1907 | 1,112 | ..... | 102,005 | ..... | 103,117 | ..... |
| 1908 | 7,406 | ..... | 46,351 | ..... | 53,757 | ..... |
| 1909 | 10,024 | ..... | 104,826 | ..... | 114,850 | ..... |
| 1910 | 4,749 | 1,922 | 67,818 | 23,517 | 72,626 | 25,439 |
| 1911 | 2,359 | 947 | 36,847 | 14,986 | 39,116 | 15,933 |
| 1912 | 8,015 | 3,661 | 35,925 | 14,206 | 43,940 | 17,567 |

1913–1916.

| Country. | 1913 | | | 1914 | | |
|---|---|---|---|---|---|---|
| | Ore (short tons). | Zinc content (short tons). | Value. | Ore (short tons). | Zinc content (short tons). | Value. |
| Canada | 8,889 | 3,498 | $123,929 | 11,250 | 4,467 | $143,247 |
| Mexico | 17,476 | 6,160 | 238,052 | 20,705 | 7,663 | 239,399 |
| Belgium | 1,674 | 1,598 | 64,970 | ..... | ..... | ..... |
| Germany | 1,558 | 841 | 55,057 | ..... | ..... | ..... |
| Siberia | 1,792 | 1,397 | 36,517 | ..... | ..... | ..... |
| Other countries | 17 | 3 | 157 | 7 | 2 | 97 |
| | 31,406 | 13,497 | 518,682 | 31,962 | 12,132 | 382,743 |

| | 1915 | | | 1916 | | |
|---|---|---|---|---|---|---|
| Canada | 11,992 | 4,710 | $177,868 | 21,908 | 8,790 | $567,259 |
| Mexico | 57,699 | 17,804 | 2,130,014 | 161,271 | 51,028 | 5,779,564 |
| France | ..... | ..... | ..... | 3,884 | 1,422 | 56,542 |
| Spain | ..... | ..... | ..... | 55,965 | 23,081 | 1,550,334 |
| Italy | 5,312 | 2,125 | 153,388 | 12,550 | 5,783 | 394,782 |
| French Africa | ..... | ..... | ..... | 4,480 | 1,857 | 129,153 |
| French East Indies | ..... | ..... | ..... | 1,653 | 746 | 55,407 |
| China and Hongkong | 5,880 | 2,738 | 119,913 | 9,641 | 4,568 | 344,192 |
| Japan | 1,369 | 499 | 77,899 | ..... | ..... | ..... |
| Australia | 76,410 | 29,723 | 1,843,801 | 113,862 | 50,601 | 3,223,184 |
| Other countries | 190 | 69 | 7,663 | 750 | 271 | 20,968 |
| | 158,852 | 57,668 | 4,510,546 | 385,964 | 148,147 | 12,121,385 |

The foregoing figures showing imports of zinc ore in 1910 do not include 10,431 short tons of ore that carried 2,645,111 pounds of zinc as an accessory constituent, an average of less than 13 per cent, which was lost in smelting the ore, and hence for the purpose of this report can not be classed with zinc ore imports so long as the present metallurgic treatment of that ore prevails. Similarly, the figures for 1911 are exclusive of 25,769 tons of other ore, carrying 6,283,437 pounds of zinc, and those for 1912 are exclusive of 18,245 tons of other ore, carrying 4,862,508 pounds of zinc. The duties on the zinc contents of this ore have since been refunded and the bonds

canceled. The ore was shipped from South American ports and largely entered through the port of New York. It is shown in the Monthly Summary of the Bureau of Foreign and Domestic Commerce under the heading of "Merchandise remaining in warehouse," mostly at New York. Such ores have entered free and have not been enumerated since 1912.

## EXPORTS.

### DOMESTIC EXPORTS.

The practice of the Bureau of Foreign and Domestic Commerce is to class all exports of zinc articles made in this country as domestic exports, whether the zinc is of domestic or foreign origin. Hence, the following table of domestic exports is duplicated in part in a later table of foreign zinc in manufactures exported with benefit of drawback. The exports of zinc ore in the table below are of domestic origin and in recent years have all gone from one mine in New Jersey. The exports of plates, sheets, pigs, or slabs are likewise probably wholly domestic, because, as shown later, all the zinc in manufactures going out under drawback came in as blocks, pigs, and sheets, and the only manufacturing process which would put any of these into the class of exports referred to is rolling into sheets. But the zinc rolling mills in this country do not use foreign spelter, hence the conclusion that the plates, sheets, pigs, and slabs of the table are of domestic origin. The exports of zinc dross are, no doubt, in part of foreign origin, but in what proportion can not be determined. However, they are not duplicated in the drawback table. The exports of manufactures, of which the value is given, include the whole of the manufactures exported with benefit of drawback, as well as whatever manufactures of domestic zinc may be exported.

*Domestic zinc ore and domestic manufactures of zinc exported from the United States, 1902–1916.*

| Year. | Zinc ore. | | Plates, sheeets, pigs, or slabs. | | Zinc dross.[a] | | All other manufactures.[b] | Total value. |
|---|---|---|---|---|---|---|---|---|
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Quantity (short tons). | Value. | Value. | |
| 1902.... | 55,733 | $1,449,104 | 3,237 | $300,557 | ..... | ..... | $114,197 | $1,863,858 |
| 1903.... | 39,411 | 987,000 | 1,521 | 163,379 | ..... | ..... | 71,354 | 1,221,733 |
| 1904.... | 35,911 | 905,782 | 10,147 | 1,094,490 | ..... | ..... | 117,957 | 2,118,229 |
| 1905.... | 30,946 | 848,451 | 5,516 | 682,254 | ..... | ..... | 150,995 | 1,680,700 |
| 1906.... | 27,720 | 733,300 | 4,670 | 583,526 | 15,887 | $1,103,706 | 204,369 | 2,624,801 |
| 1907.... | [c] 20,352 | 579,490 | 563 | 75,194 | 9,593 | 560,944 | 186,203 | 1,401,831 |
| 1908.... | [c] 26,108 | 877,745 | 2,640 | 250,254 | 8,405 | 467,403 | 88,485 | 1,683,887 |
| 1909.... | [c] 12,455 | 412,300 | 2,566 | 263,010 | 7,069 | 477,112 | 69,751 | 1,222,173 |
| 1910.... | [c] 19,711 | 649,425 | 3,990 | 426,560 | 4,729 | 380,950 | 101,336 | 1,558,271 |
| 1911.... | [c] 18,281 | 642,884 | 6,872 | 810,099 | 4,246 | 348,176 | 134,518 | 1,935,677 |
| 1912.... | [c] 23,349 | 823,997 | 6,634 | 864,292 | 205 | 17,985 | 140,027 | 1,846,301 |
| 1913.... | [c] 17,713 | 631,991 | 7,783 | 955,667 | 28 | 1,457 | 145,984 | 1,735,099 |
| 1914.... | [c] 11,110 | 388,464 | 64,802 | 8,540,668 | 2,536 | 240,944 | 210,974 | 9,381,050 |
| 1915.... | [c] 832 | 35,276 | 118,603 | 29,537,680 | 4,167 | 506,956 | 1,951,949 | 32,031,861 |
| 1916.... | 78 | 3,992 | 163,135 | 51,311,047 | 48 | 10,801 | 574,229 | 51,900,069 |

[a] Not separately enumerated prior to 1906.
[b] Not including brass.
[c] The exports consisted wholly of high-grade willemite ore from New Jersey.

*Zinc oxide exported from the United States, 1902–1916.*

| Year. | Quantity (short tons). | Value. | Year. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| 1902 | 5,358 | $433,722 | 1910 | 13,167 | $943,938 |
| 1903 | 7,215 | 578,215 | 1911 | 14,618 | 1,051,311 |
| 1904 | 8,157 | 628,494 | 1912 | 17,064 | 1,247,702 |
| 1905 | 11,280 | 810,203 | 1913 | 14,467 | 1,136,257 |
| 1906 | 15,578 | 1,149,297 | 1914 | 15,592 | 1,408,525 |
| 1907 | 13,257 | 1,069,924 | 1915 | 19,989 | 2,068,428 |
| 1908 | 12,008 | 845,070 | 1916 | 13,942 | 2,394,709 |
| 1909 | 14,846 | 1,026,377 | | | |

*Domestic brass and brass manufactures exported from the United States, 1911–1916.*

[Zinc content approximately 30 per cent by weight.]

| Year. | Bars, plates, and sheets | | Scrap and old. | | Articles made from (value). | Total value. |
|---|---|---|---|---|---|---|
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | | |
| 1911 | 1,152 | $314,089 | 9,409 | $1,703,131 | $5,352,868 | $7,370,088 |
| 1912 | 3,431 | 1,058,560 | 14,435 | 3,090,833 | 5,036,197 | 9,185,590 |
| 1913 | 3,056 | 933,949 | 10,943 | 2,292,349 | 4,719,119 | 7,945,417 |
| 1914 | 3,558 | 909,153 | 10,320 | 2,100,870 | 3,756,888 | 6,766,911 |
| 1915 | 33,136 | 12,435,908 | 5,628 | 1,259,637 | 41,117,771 | 54,813,315 |
| 1916 | 122,266 | 72,683,626 | 3,478 | 1,305,050 | 241,668,081 | 315,656,757 |

This table does not include all the brass exported in munitions. For instance, the large exports of shrapnel are included by the Bureau of Foreign and Domestic Commerce under "All other explosives," which increased in value from $651,601 in 1913 to $95,129,957 in 1915 and $394,136,334 in 1916.

### FOREIGN EXPORTS.

"Foreign zinc exports" are the exports of zinc of foreign origin which has been smelted or manufactured in this country and then shipped abroad. The following table, made up from the records of the Bureau of Foreign and Domestic Commerce, shows the total zinc exported from warehouse during the last 12 years—the exports prior to that period being of insignificant proportions—and also the foreign zinc exported in manufactures with benefit of drawback for the same period. These two items—foreign zinc exported from warehouse and foreign zinc in manufactures exported with benefit of drawback—make up the total foreign zinc going out of the country. Zinc in warehouse and deductions by liquidation being disregarded, the difference between the sum of these two exports of zinc and the total imports of zinc constitutes the foreign zinc consumed in this country. The zinc recorded in this table was not exported as zinc content of ore and blocks, pigs, etc., but as zinc smelted or manufactured from them. The reason for this method of reporting is that the zinc in bonded customs warehouse is carried on the records until the bond is canceled in the same form in which the zinc was entered for warehouse. The zinc content of the foreign ore is, of course, exported as spelter and manufactures of zinc. In the Monthly Summary of the Bureau of Foreign and Domestic Com-

merce since July 1, 1914, the exports of foreign zinc have been wholly classed as spelter; that is, as "blocks, pigs, and old."

Under present customs regulations zinc equivalent in quantity to the total recoverable zinc content must be exported to procure cancellation of bond. The quantities as given of zinc exported from warehouse are exact, but the quantities as given of zinc exported in manufactures under drawback are subject to wastage in manufacturing.

Except for a portion of the articles manufactured from foreign zinc and exported with benefit of drawback, no record is kept of the form in which the zinc is actually exported. Unless the zinc is the constituent of chief value, the actual quantity of zinc is not recorded. But each shipment on which drawback is claimed is accompanied by a manifest of the imported zinc which was used in making the articles, as well as the duty paid thereon. From these manifests is made up the statement of the total quantity of foreign zinc which went into manufactures exported with benefit of drawback, and for this reason the zinc is given in the form in which it was imported.

*Foreign zinc exported from the United States in 1905–1916.*

| Year. | Exported from warehouse. | | | | | Exported in manufactures with benefit of drawback: Blocks, pig, sheets, and all other manufactures (short tons). |
|---|---|---|---|---|---|---|
| | Ore and calamine, zinc contents.[a] | | Blocks, pigs, and old. | | All other manufactures (value). | |
| | Quantity (short tons). | Value. | Quantity (short tons). | Value. | | |
| 1905 | ..... | ..... | 19 | $816 | $1,015 | ..... |
| 1906 | ..... | ..... | 1 | 252 | 1,962 | 2 |
| 1907 | ..... | ..... | 9 | 1,023 | 1,504 | 1,555 |
| 1908 | ..... | ..... | 8 | 964 | 4,635 | 1,234 |
| 1909 | 328 | $6,429 | 6 | 752 | 521 | ..... |
| 1910 | 4,710 | 182,345 | 47 | 4,884 | 1,121 | 4,486 |
| 1911 | 10,818 | 476,233 | 458 | 21,141 | 2,701 | 3,079 |
| 1912 | 6,778 | 306,726 | 48 | 4,346 | 30,649 | 1,219 |
| 1913 | 5,406 | 214,437 | 620 | 66,919 | 6,231 | 7,459 |
| 1914 | 140 | 5,909 | 5,440 | 212,236 | 18,544 | 9,506 |
| 1915 | ..... | ..... | 12,775 | 2,355,557 | 119,104 | 255 |
| 1916 | ..... | ..... | 43,230 | 8,080,442 | 574,229 | ..... |

[a] After Aug. 6, 1909.

## CONSUMPTION.

The rapidly increasing quantity of secondary material, such as zinc skimmings, ashes, hard zinc, and scrap zinc, from which zinc is recovered in the form of spelter, alloy, pigment, or chemical, and so used again, affects the consumption of primary spelter. The total quantity of secondary zinc recovered in 1916, so far as there is available record, was 138,000 tons, as compared with 108,758 tons in 1915. For details of the recovery of secondary zinc in 1916 and previous years, see pages 812–813.

*Primary spelter consumed in the United States, 1910–1916, in short tons.*

| | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| Supply: | | | | | | | |
| Stock Jan. 1: | | | | | | | |
| In bonded warehouses | 39 | 31 | 32 | 48 | ..... | 111 | 32 |
| At smelters | 11,167 | 23,201 | 9,049 | 4,474 | 40,659 | 19,984 | 14,221 |
| Production | 269,184 | 286,526 | 338,806 | 346,676 | 353,049 | 489,519 | 667,456 |
| Imports | 1,960 | 609 | 11,115 | 6,100 | 880 | 904 | 684 |
| Total available | 282,350 | 310,367 | 359,002 | 357,298 | 394,588 | 510,518 | 682,393 |
| Withdrawn: | | | | | | | |
| Exports, foreign, from warehouse | 4,758 | 11,276 | 6,286 | 6,027 | 5,580 | 12,775 | 43,230 |
| Exports, foreign, under drawback | 4,486 | 3,079 | 1,219 | 7,459 | 4,981 | 255 | ..... |
| Exports, domestic | 3,990 | 6,872 | 6,634 | 7,783 | 64,807 | 118,603 | 163,137 |
| Stock Dec. 31: | | | | | | | |
| In bonded warehouses | 31 | 32 | 48 | ..... | 111 | 32 | 90 |
| At smelters | 23,201 | 9,049 | 4,474 | 40,659 | 19,984 | 14,221 | 17,508 |
| Total withdrawn | 36,466 | 30,308 | 18,661 | 61,928 | 95,463 | 145,886 | 223,965 |
| Apparent consumption | 245,884 | 280,059 | 340,341 | 295,370 | 299,125 | 364,632 | 458,428 |

The domestic consumption of spelter of foreign origin, both that made in this country from foreign ore and that imported directly as spelter, is a matter of much importance to American zinc producers and smelters. A certain portion of the stocks reported by the smelters as on hand at the end of the year must consist of spelter made from foreign ores, and this has not been taken into consideration in the following table, but although this omission affects the statistics of consumption for any single year it does not impair the usefulness of a table covering the length of time here given.

*Foreign zinc consumed in United States, 1910–1916, in short tons.*

| | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| Supply: | | | | | | | |
| Produced from foreign ore | 16,705 | 14,905 | 14,899 | 9,424 | 9,631 | 31,284 | 104,005 |
| Stocks in bonded warehouse | 39 | 31 | 32 | 48 | ..... | 111 | 32 |
| Imports | 1,960 | 609 | 11,115 | 6,100 | 880 | 904 | 684 |
| Total supply | 18,704 | 15,545 | 26,046 | 15,572 | 10,511 | 32,399 | 104,721 |
| Withdrawn: | | | | | | | |
| Exports from warehouse | 4,758 | 11,276 | 6,286 | 6,027 | 5,580 | 12,775 | 43,230 |
| Exports under drawback | 4,486 | 3,079 | 1,219 | 7,459 | 4,981 | 255 | ..... |
| Stocks in warehouse | 31 | 32 | 48 | ..... | 111 | 32 | 90 |
| Total | 9,275 | 14,387 | 7,553 | 13,486 | 10,672 | 13,062 | 43,320 |
| Consumption of foreign zinc | 9,429 | 1,158 | 18,493 | 2,086 | [a]—161 | 19,337 | 61,401 |

[a] The excess of withdrawals over supply may be accounted for by exports under drawback of articles manufactured from zinc imported prior to 1914.

## USES OF ZINC.

Zinc has been used in the United States chiefly for galvanizing. For several years figures of the consumption of spelter for different purposes were published by the Engineering and Mining Journal. The figures for 1910, the last published, gave 60 per cent of the spelter output as used in galvanizing, 20 per cent as used in making

brass, 11 per cent as rolled into sheet zinc, 1 per cent for the desilverization of lead, and 8 per cent for all other purposes. During 1915 and 1916 the percentage of the total output used in galvanizing must have been less than 60 per cent, for the production was much greater, and there was an actual decrease in certain lines of galvanizing, as is shown in the table below. The quantity of spelter used in making brass was very much larger than ever, and it is probable that the percentage of the total output so used was also greater than in 1910. The following figures give an idea of the relative quantity of spelter used in galvanizing certain products for which statistics were collected. Data are not at hand to show the actual percentage of the total weight contributed by the zinc coating,

*Galvanized iron and steel sheets, formed products, and tubes produced in the United States, 1913–1916, in short tons.*[a]

| | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|
| Galvanized iron and steel sheets | 922,932 | 903,834 | 790,785 | 673,462 |
| Galvanized form products [b] | 64,595 | 65,802 | 56,096 | 65,151 |
| Galvanized tubes | 298,973 | 296,832 | 314,657 | 325,935 |
| | 1,286,500 | 1,266,468 | 1,161,538 | 1,064,548 |

[a] From annual statistical reports of American Iron and Steel Institute.
[b] Articles formed or stamped from iron or steel sheets and galvanized after shaping.

This table does not include galvanized wire and galvanized cast or wrought iron or steel articles. The production of galvanized wire must have increased greatly, for the exports of wire were very large in 1915 and 1916, as shown in the table below, taken from the Monthly Summary of the Bureau of Foreign and Domestic Commerce. It is generally understood that the barbed wire used in military entanglements is galvanized; in fact, a large percentage of the wire exported is galvanized.

*Domestic wire exported from the United States, 1913–1916, in short tons.*

| | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|
| Barbed wire | 91,897 | 105,108 | 278,454 | 469,148 |
| All other wire | 121,222 | 97,465 | 251,964 | 295,839 |
| | 213,119 | 202,573 | 530,418 | 764,987 |

## PRICES AND VALUE.

### PRICES.

The price of spelter at St. Louis at the beginning of 1916 was 17.2 cents a pound. By the middle of February it had risen to 20.9 cents a pound, the high point of the year; after which it dropped sharply to 16.5 cents by the middle of March, but rose quickly again to 19⅛ cents at the middle of April. Then began a long sharp decline which brought the price to 8.8 cents a pound at the middle of July. A recovery to 10.7 cents was followed by a drop to 8.4 cents on August 10, the lowest price of the year. By fits and starts the

price rose to 13.2 cents a pound at the end of November, after which it gradually declined, closing the year at 9.75 cents a pound. For the year the average price quoted for immediate delivery at St. Louis was 13.6 cents a pound, compared with 14.2 cents a pound in 1915 and 5.1 cents in 1914.

The price of spelter in London was generally about 2 cents a pound higher during the year than at St. Louis, though for a few days in the latter part of November the London price was lower than the St. Louis price. The price at London opened at £90 a long ton (19.6 cents a pound) and after sagging slightly through January rose sharply to £111 a ton (24.1 cents a pound) at the beginning of March. This exceeded the maximum price for 1915, which was £110 a ton (23.8 cents a pound). A sharp decline to £85 a ton (18.5 cents a pound) by the middle of March was followed by a rise to £105 a ton (22.8 cents a pound) at the end of April. The great decline then set in which brought the price down to £44 a long ton (9.6 cents a pound) in the early part of July. A sharp recovery to £60 a ton (13 cents a pound) at the end of July was followed by a drop to £44 (9.6 cents a pound) in the early part of August. Then followed a series of sharp oscillations which brought the price to £60 a ton (13 cents a pound) by the beginning of December. The price declined a little through the last month of the year and at the end was £51 a ton (10.8 cents a pound). The average London price for the year was about £68 8s. 11d. a long ton (14.5 cents a pound).

The price of the "brass special" grade of spelter at Waterbury, Conn., usually averages about 0.4 cent above the St. Louis price. During 1915 and 1916, however, the differential ranged from 2.1 to 5.7 cents and averaged about 3.3 cents in 1915 and about 4.2 cents in 1916. The price of the highest grades of spelter is not quoted, but sales were reported at more than 40 cents a pound when spelter was at the high point in 1915.

The price of sheet zinc generally ranges from 2 to 2.5 cents above the St. Louis price of spelter but during 1916 it was from 4 to 9 cents above the price of spelter.

Zinc dust, mostly imported from Europe before the war, generally sold from 1 to 2 cents a pound higher than spelter. In March, 1915, the price of zinc dust began to go up, by June it had risen to 40 cents, and at the end of the year it was nearly 40 cents. In 1916 the price declined evenly through the year, closing at 20 to 33 cents.

### PRICE CURVES, 1914–1916.

Plate II shows graphically for the years 1914–1916 the relations of the weekly average St. Louis price of spelter, the weekly average London price of spelter, the weekly average price of 60 per cent zinc blende concentrates at Joplin, Mo., and the weekly sales of concentrates in the Joplin region as a whole. The price of spelter has been taken from market reports, and the price of zinc blende and the figures of weekly sales are those published in the Joplin daily papers. To eliminate the sharp weekly fluctuations and to obtain a curve more easily comparable with the price curves, the weekly sales have been averaged by months, the result being shown by the broken line.

The curve of the London price of spelter for the first seven months of 1914 shows that spelter was about two-fifths of a cent higher in

St. Louis than in London. Through this period the price was about at a level. With the outbreak of the war London became the center of the demand for spelter for munitions and the London price became higher than the St. Louis price except for short intervals. The curve is very irregular, with a sharp rise during the early months of the war, culminating in the week ending June 12, 1915, when spelter quotations for ordinary grades averaged above 25 cents. The curve for the last half of 1915 shows rapid and extreme changes in the price of spelter, due to the changing demands and exigencies of the war, but the price was always rising. This condition continued through more than the first quarter of 1916 but was followed by a great decline in May and June, significant of overbuilt smelting capacity and overproduction in the United States.

## VALUE.

In 1915 the average price quoted for prime western spelter for immediate delivery at St. Louis was 14.2 cents a pound. Large quantities of spelter were sold for future delivery at considerable reductions in price. Returns from each producer showed an average received of 12.4 cents. In 1916 the average price quoted for spelter for immediate delivery at St. Louis was 13.6 cents a pound, and the average price received for spelter of all qualities—prime western, brass special, and high grade—was 13.4 cents. The smaller difference between the price quoted and the price received in 1916 is probably due to increase in domestic consumption, to decrease in sales for future delivery, and to the production of a larger proportion of high-grade spelter.

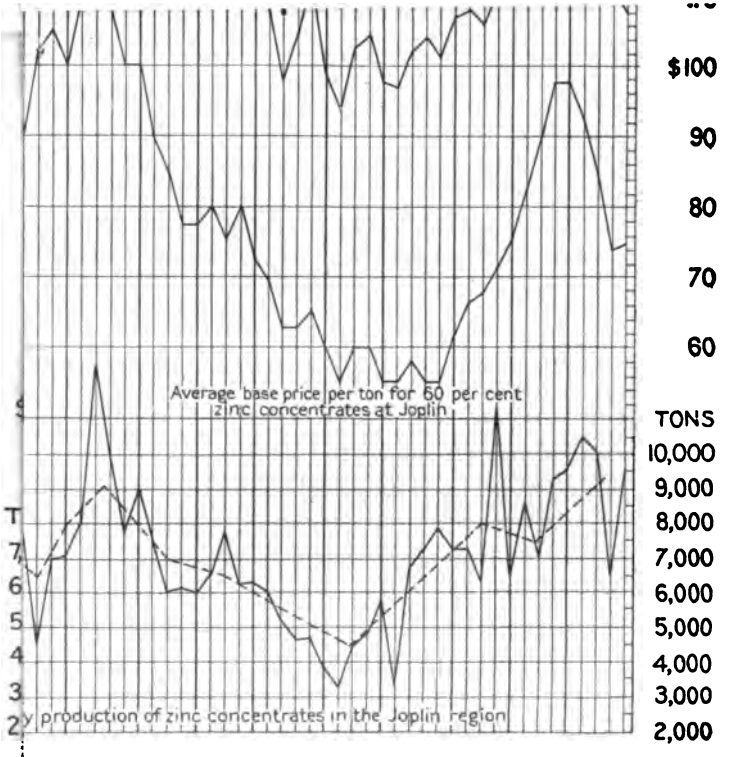
673,462
65,151
325,935
1,064,548

The production of primary spelter from domestic ores in 1916 was 563,451 short tons, valued at $151,005,000, based on the average selling price, as compared with 458,135 short tons, valued at $113,617,000, based on the average St. Louis price in 1915—an increase of 105,316 tons, or about 23 per cent, in quantity and an increase of $37,388,000, or about 33 per cent, in value.

*Domestic primary spelter produced in the United States, 1909–1916.*

| Year. | Quantity (short tons). | Average price at St. Louis. | Value. | Year. | Quantity (short tons). | Average price at St. Louis. | Value. |
|---|---|---|---|---|---|---|---|
| 1909 | 230,225 | $0.054 | $24,864,000 | 1913 | 337,252 | $0.056 | $37,772,000 |
| 1910 | 252,479 | .054 | 27,268,000 | 1914 | 343,418 | .051 | 35,029,000 |
| 1911 | 271,621 | .057 | 30,965,000 | 1915 | 458,135 | [a] .124 | 113,617,000 |
| 1912 | 323,907 | .069 | 44,699,000 | 1916 | 563,451 | [a] .134 | 151,005,000 |

[a] Average value of all grades based on total sales during year.




OF ZINC CONCENTRATES IN THE JOPLIN REGION IN 1914-15.

# CADMIUM.

By C. E. SIEBENTHAL.

## INTRODUCTION.

A brief account of the production, resources, metallurgy, and uses of cadmium was given as a chapter in Mineral Resources, 1908. A more detailed report is in preparation and will be published as a bulletin.

Outside the United States, the chief output of cadmium comes from the zinc-producing regions of Silesia, where it is recovered mainly as a by-product in the distillation of zinc. No cadmium is recovered in the United States in the distillation of zinc ores, but most of the output is gained from bag-house dusts at lead smelters that treat lead ores containing more or less zinc. In England a little cadmium is recovered in the purification of the solution of zinc sulphate in the manufacture of lithopone, and for several years some has been recovered in the same way in the United States. Another source of cadmium is the residues left after the manufacture of zinc chloride from low-grade zinc ores and from zinc ashes and drosses. Still other sources which may attain importance are the anode mud resulting from the vats used in the electrolytic refining of spelter and the slimes from the leaching and electrolytic reduction of zinc ores.

## PRODUCTION.

Cadmium was first produced in the United States by the Grasselli Chemical Co. in 1907. One by one other companies undertook the recovery of cadmium until there are now four producers—the American Smelting & Refining Co., the Grasselli Chemical Co., the Krebs Pigment & Chemical Co., and the United States Smelting Co.

The following table, compiled from reports by each producer of cadmium in the United States and from official reports of the German Government, shows that the production of cadmium in the United States since 1910 has made rapid gains on that of Germany. Taken together the production of these two countries constitutes practically the whole cadmium output of the world.



45083°—M R 1916, PT 1——53

*Metallic cadmium and cadmium sulphide produced in the United States and Germany, 1907–1916.*

| Year | United States. | | | | | | Germany. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Metallic cadmium. | | | Cadmium sulphide. | | | Metallic cadmium. | | |
| | Quantity (pounds). | Value | Average price per pound. | Quantity (pounds). | Value. | Average price per pound. | Quantity (pounds). | Value. | Average price per pound. |
| 1907 | 14,000 | $14,350 | $1.025 | (a) | ..... | ..... | 72,639 | $60,757 | $0.84 |
| 1908 | 8,000 | 6,000 | .75 | (a) | ..... | ..... | 72,741 | 48,590 | .67 |
| 1909 | 5,300 | 2,783 | .525 | (a) | ..... | ..... | 81,962 | 46,777 | .57 |
| 1910 | 4,700 | 2,585 | .55 | (a) | ..... | ..... | 90,516 | 39,309 | .43 |
| 1911 | 26,152 | 17,566 | .67 | 2,392 | $1,674 | $0.70 | 93,861 | 53,372 | .57 |
| 1912 | 52,508 | 39,875 | .76 | 8,998 | 6,400 | .71 | 94,262 | 63,507 | .67 |
| 1913 | 54,198 | 41,838 | .77 | 17,302 | 12,136 | .70 | 81,993 | 63,641 | .78 |
| 1914 | [b] 91,409 | 81,205 | .89 | 22,723 | 20,241 | .88 | (c) | ..... | ..... |
| 1915 | 91,415 | 108,443 | 1.19 | 10,624 | 12,057 | 1.13 | (c) | ..... | ..... |
| 1916 | 135,212 | 210,931 | 1.56 | 22,176 | 27,942 | 1.26 | (c) | ..... | ..... |
| | 482,894 | 525,576 | ..... | 84,215 | 80,450 | ..... | ..... | ..... | ..... |

[a] No production.
[b] Exclusive of 4,225 pounds of cadmium in residues sold for export.
[c] No figures of the cadmium production of Germany later than 1913 are available.

The cadmium output of the United States comes in two forms, metallic stick cadmium and the pigment cadmium sulphide, "cadmium-yellow." The domestic production in 1907 was nearly sufficient to supply the home demand—a fact shown by the small imports for that year—but the next year the quantity of cadmium imported was about doubled, and in 1909–1912 the imports of cadmium were as large as before the beginning of the production of cadmium in the United States. The domestic production has made great strides in the last few years, however, and as a result the imports of cadmium are naturally growing small. As the imports have come largely from Germany they have been practically extinguished for the last three years by the war.

## IMPORTS.

Cadmium is imported into the United States as metallic stick cadmium and as the pigment cadmium sulphide. The former is free of duty; the latter is dutiable at 30 per cent ad valorem. The value of the imports for consumption of metallic cadmium for 1903 to 1913, inclusive, is given in the table below, which is taken from the records of the Bureau of Foreign and Domestic Commerce. The quantities for the period prior to July 1909, were not recorded by that bureau, and have been computed by dividing the values of the imports by the average price of cadmium for the corresponding year in Germany, from which the cadmium was imported. The quantity and value of cadmium imported as a pigment are not recorded separately by the Bureau of Foreign and Domestic Commerce.

*Cadmium imported and entered for consumption in the United States, 1903–1916.*

| Year. | Quantity (pounds). | Value. | Year. | Quantity (pounds). | Value. |
|---|---|---|---|---|---|
| 1903 | [a] 8,679 | $4,565 | 1910 | 4,060 | $2,295 |
| 1904 | [a] 7,655 | 4,524 | 1911 | 5,367 | 3,870 |
| 1905 | [a] 8,138 | 5,298 | 1912 | 5,250 | 3,764 |
| 1906 | [a] 13,808 | 10,522 | 1913 | 1,656 | 1,232 |
| 1907 | [a] 1,953 | 1,633 | 1914 | 441 | 368 |
| 1908 | [a] 3,567 | 2,390 | 1915 | 269 | 284 |
| 1909 first half | [a] 6,659 | 4,559 | 1916 | | |
| 1909 second half | 2,203 | | | | |

[a] Prior to July, 1909, the quantities are computed as noted on page 834.

## EXPORTS.

Complete statistics of the exports of cadmium are not available, but it is known that domestic cadmium has been largely exported during the war. According to the Bureau of Foreign and Domestic Commerce the following quantities of cadmium were exported through the port of New York in the last quarter of 1916: In October, 33,244 pounds, valued at $55,259; in November, 4,900 pounds, valued at $5,100; and in December, 1,044 pounds, valued at $1,530. Of the exports in October, 23,210 pounds went to France, 9,984 pounds to Italy, and 50 pounds to Dutch Guiana.

Unrefined cadmium in cadmium residues has also been exported.

## PRICES AND VALUE.

The price of stick cadmium through the first quarter of 1916 was listed as $1.50 a pound in retail lots. During the second quarter the price was from $1.25 to $1.50 a pound, and through the remainder of the year the quotations remained practically stationary at $1.30 to $1.50 a pound. The average price for 1916 as calculated from sales was $1.56 a pound, compared with an average of $1.19 a pound in 1915. The price in London during the first six months of 1916 was 8s. 6d. ($2) a pound; during the last six months it ranged from 7s. 6d. ($1.80) to 7s. 9d. ($1.85) a pound.

The average selling price of cadmium sulphide in the United States in 1916 was $1.26 a pound, compared with $1.13 a pound in 1915.

The value of the cadmium produced in the United States in 1916, calculated at the average selling price, was $210,931, compared with $108,443 in 1915, and the value of the cadmium sulphide produced was $27,942, as against $12,057 in 1915.

# LEAD.

By C. E. SIEBENTHAL.

## SUMMARY.

The following tabular statement gives the general items regarding domestic production and consumption of refined lead, from figures compiled by this Survey.

*Summary of statistics of refined lead, 1911–1916, in short tons.*

| | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|
| Total production of refined primary leads in the United States | 486,979 | 480,894 | 462,460 | 542,122 | 550,055 | 571,134 |
| Production of desilverized lead in the United States | 331,032 | 339,646 | 330,593 | 383,903 | 388,594 | 403,619 |
| Production of soft lead in the United States (including desilverized soft) | 191,614 | 171,037 | 161,300 | 201,725 | 205,462 | 235,759 |
| Production of antimonial lead in the United States | 14,078 | 13,552 | 16,665 | 16,667 | 23,224 | 24,088 |
| Production of lead from domestic ores | 391,995 | 392,517 | 411,878 | 512,794 | 507,026 | 552,228 |
| Production of secondary lead in the United States | 54,284 | 67,168 | 72,834 | 61,062 | 78,900 | 96,300 |
| Consumption of primary lead in the United States (disregarding stocks) | 353,268 | 394,113 | 414,283 | 451,264 | 430,252 | 461,238 |

a "Primary lead," which is produced directly from ore, is here distinguished from "secondary lead," which is obtained by refining skimmings, drosses, and old metals. The statistics of secondary lead are given on p. 844. Wherever in this report the word "lead" is used without qualification it means primary lead.

The output of refined lead in the United States from domestic ores in 1916 was 552,228 short tons, valued at $76,207,000, at the average price of refined lead in New York, compared with 507,026 tons, valued at $47,660,000 in 1915—a gain in quantity of 45,202 tons, or nearly 10 per cent, and a gain in value of $28,547,000, or nearly 60 per cent.

## INTRODUCTION.

Though the publication of this chapter has been so greatly delayed by press of work growing out of the war that the report has value only for purposes of statistical record, nevertheless the essential figures have been available since the beginning of 1917. An estimate of the production of refined lead in 1916 was published in the form of a press bulletin on January 3, 1917. This estimate was based on reports received from every lead smelter in operation, giving the actual production for the first 10 or 11 months of 1916 and estimates for the remainder of the year. The complete figures for the production and consumption of primary refined lead and for the imports

and exports of lead in ore and bullion were given in an advance statement published April 9, 1917. The present report contains, in addition to the statistics given in that statement, tables and curves showing production, value, consumption, imports, exports, and prices for a period of years.

The statistics of production of lead in this country in 1916 have been compiled by the United States Geological Survey from confidential reports submitted by each lead-smelting company in operation during the year. The statistics of the recovery of secondary lead were also collected by the Geological Survey. The statistics of domestic consumption are taken in part from the smelter returns and in part from the records of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce, and the statistics of foreign production and consumption are compiled from the sources indicated in connection with the tables here presented.

## PRODUCTION.

### PRODUCTION AND VALUE.

The refined lead produced in the United States from 1720 to 1914 from domestic ores and from foreign ores and base bullion and its value at the average price in New York are shown in a table in the chapter on lead in Mineral Resources for 1914. Details of later years are shown in the table below.

*Production, price per pound, and value of refined lead in the United States, 1720–1916.*

| Year. | Desilverized lead.[a, b] | Soft lead.[c] | Total production.[b] | From domestic ores and base bullion.[b] | From foreign ores. | From foreign base bullion. | Price per pound at New York. | Value. |
|---|---|---|---|---|---|---|---|---|
| | *Short tons.* | *Short tons.* | *Short tons.* | *Short tons.* | *Short tons.* | *Short tons.* | | |
| 1720–1905 | 5,251,079 | 2,081,836 | 7,332,915 | 6,032,383 | 1,300,532 | | ..... | $634,403,000 |
| 1906 | 313,896 | 90,860 | 404,746 | 336,200 | 28,803 | 39,743 | $0.057 | 46,141,000 |
| 1907 | 313,588 | 99,801 | 413,389 | 352,381 | 24,041 | 36,967 | .053 | 43,819,000 |
| 1908 | 295,552 | 101,012 | 396,564 | 311,666 | 11,509 | 73,389 | .042 | 33,311,000 |
| 1909 | 329,751 | 117,158 | 446,909 | 352,839 | 21,754 | 72,316 | .043 | 38,434,000 |
| 1910 | 328,954 | 141,318 | 470,272 | 375,402 | 18,065 | 76,805 | .044 | 41,384,000 |
| 1911 | 331,032 | 155,947 | 486,979 | 391,995 | 10,764 | 84,220 | .045 | 43,828,000 |
| 1912 | 339,646 | 141,248 | 480,894 | 392,517 | 11,572 | 76,805 | .045 | 43,280,000 |
| 1913 | 330,593 | 131,867 | 462,460 | 411,878 | 13,223 | 37,359 | .044 | 40,696,000 |
| 1914 | 383,903 | 158,219 | 542,122 | 512,794 | 7,639 | 21,689 | .039 | 42,286,000 |
| 1915 | 388,594 | 161,461 | 550,055 | 507,026 | 9,581 | 33,448 | .047 | 51,705,000 |
| 1916 | 403,619 | 167,515 | 571,134 | 552,228 | 6,085 | 12,821 | .069 | 78,817,000 |
| | 9,010,197 | 3,548,242 | 12,558,439 | 10,529,309 | 2,029,130 | | ..... | 1,138,104,000 |

[a] Desilverized soft lead is included; for quantity see page 841.
[b] Antimonial lead is excluded; for quantity see page 842.
[c] Desilverized soft lead is excluded.

### PRODUCTION BY STATES.

The production of refined lead can with difficulty be apportioned according to sources of ore, owing to the fact that lead refiners treat products already smelted, whose origin may, as in custom refining, be unknown to them, because the identity of the ore is preserved only as far as the smelter. Accordingly, the following table is compiled, so far as possible, from smelter figures. It includes "pig lead" reported by all known smelters running on Mississippi Valley or

southern lead ores and "work lead" produced at all other lead smelters in this country. The greater part of the product reported by smelters operated in conjunction with refineries is stated in terms of refined lead. A like part of the antimonial lead is thus eliminated from the "work lead" produced and appears only in the figures of production of antimonial lead.

In addition to the domestic lead ores smelted in this country, small quantities of domestic lead ore have been exported to smelters in Canada. In 1912 soft lead amounting to 63 tons was smelted from Wisconsin ores at Canadian smelters, and in 1913 soft lead amounting to 37 tons from Wisconsin ores and desilverized lead amounting to 98 tons from Idaho and Washington ores were smelted in Canadian smelters. The desilverized lead smelted in Canada from Washington ores amounted to 31 tons in 1914, to 137 tons in 1915, and to 2,001 tons in 1916.

*Primary lead smelted or refined in the United States, 1907–1916, by sources, in short tons.*

| Source of ore. | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|---|---|
| Domestic ore: | | | | | | | | | | |
| Alaska | ..... | 3 | 69 | 75 | 51 | 45 | 6 | ..... | 358 | 659 |
| Arizona | 2,418 | 1,464 | 1,507 | 948 | 3,498 | 3,891 | 4,901 | 5,601 | 6,953 | 15,328 |
| Arkansas [a] | 15 | ..... | 14 | ..... | 15 | ..... | ..... | 52 | 51 | 170 |
| California | 938 | 515 | 977 | 1,207 | 615 | 811 | 3,294 | 3,698 | 5,606 | 3,633 |
| Colorado | 52,552 | 28,729 | 30,865 | 38,542 | 30,442 | 37,639 | 42,840 | 41,198 | 32,352 | 33,046 |
| Idaho | 123,292 | 98,464 | 103,747 | 109,951 | 117,335 | 127,786 | 137,802 | 177,827 | 160,680 | 170,059 |
| Illinois [a] | 498 | 362 | 273 | 263 | 308 | 513 | 619 | 427 | 919 | 670 |
| Iowa [a] | 225 | 110 | 15 | ..... | ..... | ..... | ..... | 34 | ..... | ..... |
| Kansas [a] | 1,798 | 2,293 | 2,763 | 1,308 | 2,522 | 1,937 | 1,504 | 1,043 | 1,320 | 1,737 |
| Kentucky [a] | 75 | ..... | ..... | 50 | ..... | 91 | 16 | 16 | 95 | 37 |
| Missouri [a] | 122,856 | 122,451 | 141,105 | 161,659 | 182,203 | 162,610 | 152,430 | 194,275 | 195,634 | 218,253 |
| Montana | 2,145 | 2,320 | 1,451 | 1,943 | 2,484 | 2,517 | 3,256 | 4,386 | 4,853 | 4,961 |
| Nevada | 3,480 | 3,796 | 4,792 | 2,246 | 1,082 | 5,699 | 6,142 | 5,996 | 7,664 | 11,858 |
| New Hampshire | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 3 | 46 |
| New Mexico | 2,047 | 586 | 1,350 | 1,890 | 1,371 | 2,511 | 1,821 | 741 | 2,157 | 3,290 |
| North Carolina | ..... | ..... | ..... | 2 | 35 | 34 | 10 | ..... | ..... | ..... |
| Oklahoma [a] | 404 | 1,409 | 2,268 | 1,805 | 1,925 | 2,500 | 3,214 | 3,916 | 4,346 | 10,969 |
| Oregon | 5 | 7 | 7 | ..... | 11 | 21 | 37 | 17 | 11 | 9 |
| Pennsylvania | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 6 | ..... |
| South Dakota | ..... | 13 | ..... | 8 | 33 | 12 | 7 | 2 | 5 | 12 |
| Tennessee [a] | 16 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 8 | ..... |
| Texas | 12 | 42 | 44 | 36 | 57 | 30 | 108 | 89 | 111 | 26 |
| Utah | 55,540 | 42,455 | 66,648 | 60,605 | 54,933 | 60,664 | 71,069 | 88,976 | 106,105 | 111,789 |
| Virginia [a] | 83 | 13 | ..... | 87 | 400 | 85 | 878 | 143 | 457 | 740 |
| Washington | 341 | 391 | 120 | 339 | 612 | 53 | 9 | 2 | 11 | 217 |
| Wisconsin [a] | 3,573 | 4,013 | 3,252 | 3,909 | 3,946 | 3,301 | 2,639 | 1,819 | 2,632 | 3,121 |
| Wyoming | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 6 | ..... |
| Undistributed | 896 | 36 | 317 | 101 | 48 | 120 | 63 | 99 | 116 | 123 |
| Zinc residues | 1,890 | 1,290 | 1,735 | 2,237 | 1,987 | 3,131 | 3,765 | 4,125 | 4,562 | 5,478 |
| | 375,099 | 310,762 | 363,319 | 389,211 | 405,863 | 415,395 | 436,430 | 534,482 | 537,012 | 596,221 |
| Foreign ore: | | | | | | | | | | |
| Africa | 288 | ..... | 3,150 | 3,310 | 582 | 1,774 | 5,976 | 2,942 | ..... | 328 |
| Canada | 2,607 | 162 | 66 | 25 | 122 | 29 | 16 | 2 | 1,174 | 1,231 |
| Central America | 23 | 12 | 20 | 3 | 28 | ..... | ..... | ..... | 1 | 7 |
| Mexico | 20,204 | 10,145 | 16,944 | 11,704 | 7,333 | 7,407 | 4,512 | 2,386 | 5,437 | 1,917 |
| South America | 919 | 1,186 | 1,536 | 2,996 | 2,677 | 2,332 | 2,617 | 1,821 | 2,829 | 2,366 |
| Other foreign | ..... | 4 | 38 | 27 | 22 | 30 | 102 | 488 | 140 | 236 |
| Foreign base bullion: | | | | | | | | | | |
| Canada | 2,716 | 179 | 1,500 | ..... | ..... | ..... | ..... | ..... | ..... | 1,072 |
| Mexico | 34,251 | 73,210 | 70,816 | 76,805 | 84,220 | 76,806 | 37,359 | 21,689 | 33,173 | 11,598 |
| South America | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 275 | 151 |
| | 61,008 | 84,898 | 94,070 | 94,870 | 94,984 | 88,377 | 50,582 | 29,328 | 43,029 | 18,906 |
| Grand total | 436,107 | 395,660 | 457,389 | 484,081 | 500,847 | 503,772 | 487,012 | 563,810 | 580,041 | 615,127 |

[a] The lead produced by these States is nonargentiferous or soft lead.

## SOFT LEAD.

The lead ores of the Mississippi Valley are almost free from silver, and the lead produced from them is known as "soft lead."

A little lead ore of this kind is also mined in Washington and other Western States, but in the last few years this ore has been smelted by plants treating argentiferous lead ore and thus the resulting lead has not been distinguished from the desilverized product of those plants. With two exceptions, the smelters running exclusively on these soft-lead ores do not desilverize their product. Their output is shown in the column headed "Soft lead" in the table on page 838, giving the production of refined lead for 1720–1916. However, considerable soft-lead ore has been annually smelted and some purchased pig soft lead has been desilverized by the silver-lead smelters. Since 1904 the St. Louis Smelting & Refining Co. has regularly desilverized its product. In 1915 the St. Joseph Lead Co. installed desilverizing kettles and a part of its product has since been desilverized. This desilverized soft lead, for the years prior to 1906, has not been recorded separately from the lead produced from silver-lead ores, though the lead content of the soft-lead ores so smelted and desilverized has been recorded since 1894. Since 1906 the quantity of soft lead produced by each State has been recorded, as shown in part in the preceding table. In the following table the undesilverized output of the soft-lead smelters is given in the first column and the refined lead output from soft-lead ores smelted and desilverized is given in the second column. The figures do not give the total quantity of lead recovered from soft-lead ores, for the lead recovered in the form of pigments,which are made principally from soft-lead ores, should be taken into account. On this combined basis of calculation, the soft lead recovered in 1916 was about 44 per cent of the total domestic production of refined lead plus the domestic lead in pigments, compared with 42 per cent in 1915.

*Soft lead produced in the United States, 1907–1916, in short tons.*

| Year. | Undesilverized. | Desilverized. | Total soft lead. |
|---|---|---|---|
| 1907 | 99,801 | 29,829 | 129,630 |
| 1908 | 101,012 | 29,869 | 130,881 |
| 1909 | 117,158 | 32,532 | 149,690 |
| 1910 | 141,318 | 27,952 | 169,270 |
| 1911 | 155,947 | 35,667 | 191,614 |
| 1912 | 141,248 | 29,789 | 171,037 |
| 1913 | 131,867 | 29,433 | 161,300 |
| 1914 | 158,219 | 43,506 | 201,725 |
| 1915 | 161,461 | 44,091 | 205,462 |
| 1916 | 167,515 | 68,244 | 235,759 |

## ANTIMONIAL LEAD.

The production of by-product antimonial lead from argentiferous lead ores derived from all sources, as reported by all lead refineries operating in this country, is shown for the period 1871–1906 (earlier years being estimated from the output of desilverized lead) in a table in the chapter on lead in Mineral Resources, 1914. The figures for later years are given in the table below. Since 1909 producers have been asked to distinguish between the by-product antimonial lead

derived from ore and bullion of foreign origin and that from domestic ores. Inasmuch as the antimonial skimmings are worked up in batches, the output of antimonial lead in any one year does not necessarily correspond strictly to the bullion refined during that year, hence the antimonial lead output is distributed as between domestic and foreign in proportion to the lead refined from domestic and from foreign bullion during the year. This method has given fairly consistent results up to 1915. For the period 1909 to 1914, inclusive, the domestic antimonial lead reported amounted to 4.8 per cent of the refined lead produced from domestic bullion and the foreign antimonial lead equaled 4.5 per cent of the lead smelted and refined from foreign ores and bullion. The total antimonial lead produced during the period 1907–1916 was equal to 5.16 per cent of the total lead refined from domestic and foreign bullion during that period. Since the beginning of the war, however, the returns have been inconsistent and it is not believed that they represent accurately the distribution as between domestic and foreign sources. For this reason, only the total production of by-product antimonial lead is given in the table below.

*By-product antimonial lead produced in the United States, 1907–1916.*

| Year. | Total lead refined from base bullion (short tons) | Percentage of by-product antimonial lead. | Total. | | Antimony content. | | Lead content, by difference (short tons). |
|---|---|---|---|---|---|---|---|
| | | | Quantity (short tons) | Value. | Quantity (short tons). | Percentage. | |
| 1907 | 283,759 | 3.5 | 9,910 | $1,322,985 | 1,561 | 15.8 | 8,349 |
| 1908 | 265,683 | 5.1 | 13,629 | 1,264,771 | 2,440 | 17.9 | 11,189 |
| 1909 | 297,219 | 4.3 | 12,896 | 1,231,019 | 2,360 | 18.3 | 10,536 |
| 1910 | 301,002 | 4.7 | 14,069 | 1,338,090 | 2,229 | 15.8 | 11,840 |
| 1911 | 295,365 | 4.8 | 14,078 | 1,380,556 | 2,254 | 16.0 | 11,824 |
| 1912 | 309,867 | 4.4 | 13,552 | 1,311,348 | 1,949 | 14.4 | 11,603 |
| 1913 | 301,160 | 5.5 | 16,665 | 1,591,854 | 2,508 | 15.0 | 14,157 |
| 1914 | 340,397 | 4.9 | 16,667 | 1,572,167 | 2,693 | 16.2 | 13,974 |
| 1915 | 344,593 | 6.7 | 23,224 | 3,665,736 | 3,425 | 14.8 | 19,799 |
| 1916 | 335,375 | 7.2 | 24,038 | 4,483,582 | 3,496 | 14.5 | 20,542 |
| Average | | 5.16 | | | | 15.7 | |

Details of the production and consumption of antimony in the United States are given in the chapter on antimony in Mineral Resources, 1916.

## LEAD PIGMENTS.

### PIGMENTS SMELTED DIRECTLY FROM ORE.

In addition to leaded zinc oxide and zinc-lead oxide, which are noted more particularly in connection with the production of zinc pigments, two other lead pigments are made directly from ore, namely, sublimed white lead and sublimed blue lead. Sublimed white lead consists of lead sulphate 75 per cent, lead oxide 20 per cent, and zinc oxide 5 per cent. Sublimed blue lead consists of lead sulphate 50 to 53 per cent, lead oxide 41 to 38 per cent, with small proportions of lead sulphide, lead sulphite, and zinc oxide. Zinc-lead oxide contains from 46 to 50 per cent of lead sulphate, from 52 to 46 per cent of zinc oxide, and a small quantity of zinc sulphate. No zinc-lead oxide is made at present. Leaded zinc oxide may vary

from 4 to 20 per cent in lead sulphate, the remainder being zinc oxide, with a small portion of zinc sulphate.

*Lead content of pigments smelted from ore in the United States, 1907–1916, in short tons.*

| | | | |
|---|---|---|---|
| 1907 | 7,099 | 1912 | 10,323 |
| 1908 | 8,278 | 1913 | 10,998 |
| 1909 | 7,292 | 1914 | 11,914 |
| 1910 | 7,603 | 1915 | 12,782 |
| 1911 | 7,678 | 1916 | 13,252 |

In order to avoid disclosing individual business, the statistics of production of leaded zinc oxide and of sublimed lead (basic sulphate white and blue lead) are combined with those of zinc oxide. The sales of these pigments in 1916 amounted to 135,606 short tons, valued at $23,515,803, compared with 141,383 short tons, valued at $14,962,461, in 1915. The output of sublimed lead decreased somewhat, but that of leaded zinc oxide increased nearly 25 per cent.

## PIGMENTS MANUFACTURED FROM PIG LEAD.

*Manufactured lead pigments marketed in 1915–16.*

| Pigment. | 1915 | | | 1916 | | |
|---|---|---|---|---|---|---|
| | Quantity (short tons) | Value. | Average price per ton. | Quantity (short tons). | Value. | Average price per ton. |
| Basic carbonate white lead: | | | | | | |
| In oil | 122,194 | $15,879,835 | $129.96 | 96,041 | $16,560,137 | $172.43 |
| Dry | 33,907 | 3,513,856 | 103.63 | 32,938 | 4,714,343 | 143.13 |
| Red lead | 19,435 | 2,397,900 | 123.38 | 23,035 | 3,933,566 | 170.76 |
| Orange mineral | | | | | | |
| Litharge | 26,118 | 2,822,415 | 108.06 | 37,739 | 5,853,543 | 155.11 |
| | 201,654 | 24,614,006 | ..... | 189,753 | 31,061,589 | ..... |

## SECONDARY LEAD.

Secondary lead is obtained mainly from skimmings, drosses, old metal, and alloys, such as babbitt, solder, and type metal. The recovery of lead by refining these materials constitutes an integral part of the lead industry. This business is carried on mostly at small refineries scattered over the United States, but the large smelters and refineries working primary lead frequently find it advantageous to incorporate material from secondary sources. The product of such secondary refineries is of two classes—pig lead and lead in alloys. The lead in alloys may have been recovered in the form of pig lead and alloyed at the refinery, or it may have been refined as an alloy, being brought to the desired composition by the addition of the requisite metal.

*Secondary lead produced in the United States, 1909–1916, in short tons.*

| | Pig lead. | Lead in alloys. | Total recovered lead. | Value |
|---|---|---|---|---|
| 1909 | 18,360 | 23,327 | 41,687 | $3,585,000 |
| 1910 | 29,492 | 25,930 | 55,422 | 4,877,000 |
| 1911 | 27,389 | 26,895 | 54,284 | 4,886,000 |
| 1912 | 30,266 | 36,902 | 67,168 | 6,045,000 |
| 1913 | 33,104 | 39,730 | 72,834 | 6,409,000 |
| 1914 | 29,827 | 31,725 | 61,062 | 4,763,000 |
| 1915 | 36,400 | 42,500 | 78,900 | 7,416,000 |
| 1916 | 56,700 | 39,600 | 96,300 | 12,289,000 |

## MINE PRODUCTION.

The following table shows for each lead-producing State the total quantity of lead-bearing ores produced and the output of each kind of lead-bearing ore. The column headed "All other ores" includes copper ore, copper-lead ore, and dry or siliceous ore. "Dry" ores produced in Colorado contained 12,252 short tons of lead, and in Nevada, 4,052 tons. This lead, as in other States, was concentrated from parts of the ore from certain counties, however, and was not distributed through the whole of the "All other ore" credited to Colorado and Arizona. The total crude ore yielding either gold, silver, copper, lead, or zinc is given for each lead-producing State, so that a comparison may be made of the relative extent of deep-mining operations in these States, of which the quantity of crude ore raised is the best measure. As shown by the table, Missouri takes a dominating position in the production of crude lead ore and lead-bearing zinc ores, having produced over two-third of the crude lead ore and nearly two-thirds of the crude lead-bearing zinc ore mined in the United States in 1916 and occupied the first rank in output of crude ore carrying any or all of the five metals named above.

The table also gives the quantity of lead contained in the crude ores of each State in 1916 and the lead content of each kind of lead-bearing ore. The percentage of lead contained in the lead ore, the lead-zinc ore, and the zinc ore of each State is also given. The lead content of lead ore, in States having a considerable production, ranged from 27.7 per cent in Washington, down to 3.7 per cent in Missouri; the average for all the States was 5.7 per cent. The lead-zinc ores were somewhat less rich in lead than the lead ores, averaging 3.5 per cent. The average lead content of the zinc ores was 0.3 per cent, this low figure being due to the preponderance of low-grade lead-bearing zinc ores in the Central States. Of the total mine production of lead in 1916, a quantity corresponding to 72.3 per cent was derived from lead ores, 16 per cent from lead-zinc ores, 8.4 per cent from zinc ores, and 3.3 per cent from all other ores. The figures of mine production of lead are taken from the chapters on gold, silver, copper, lead, and zinc in the various States, as indicated in the prefatory note.

*Mine production of lead in the United States in 1916, by States and kinds of ore.*

| State. | Lead ores. | | | Lead-zinc ores. | | | Zinc ores. | | | All other ores (short tons). | | Total (short tons). | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crude ore (short tons). | Lead content. | | Crude ore. | Lead content. | | Crude ore. | Lead content. | | Crude ore. | Lead content. | Crude ore. | Lead content. |
| | | Quantity (short tons). | Percentage. | | Quantity (short tons). | Percentage. | | Quantity (short tons). | Percentage. | | | | |
| Alaska | | | | | | | | | | 4,166,062 | 820 | 4,166,062 | 820 |
| Arizona | 73,747 | 10,644 | 13.6 | 55,956 | 2,770 | 5.1 | 52,659 | 138 | 0.2 | 16,851,448 | 579 | 17,033,810 | 13,531 |
| Arkansas | | | | | | | 249,000 | 272 | .1 | | | 249,000 | 272 |
| California | 32,763 | 4,307 | 13.2 | | | | 29,079 | 1,856 | 6.3 | 3,125,800 | 47 | 3,187,642 | 6,204 |
| Colorado | 159,247 | 13,714 | 8.6 | 291,489 | 9,196 | 3.2 | 151,497 | 295 | .2 | 2,095,010 | 12,252 | 2,697,243 | 35,457 |
| Idaho | 1,373,579 | 128,508 | 9.3 | 1,136,553 | 58,636 | 5.1 | 23,158 | 343 | 1.5 | 164,755 | 64 | 2,718,045 | 187,541 |
| Illinois | | | | | | | 288,100 | 462 | .2 | | [a] 610 | 288,109 | 1,072 |
| Iowa | | | | | | | [b] 1,000 | 14 | .2 | | | [b] 1,000 | 14 |
| Kansas | | | | | | | 774,400 | 1,648 | .2 | | | 774,400 | 1,648 |
| Kentucky | | | | | | | | | | | [a] 153 | | [a] 153 |
| Missouri | 5,467,500 | 201,253 | 3.7 | | | | 13,196,400 | 31,835 | .2 | 124 | | 18,664,024 | 233,088 |
| Montana | 7,231 | 1,032 | 14.2 | 702,885 | 5,057 | .7 | 388,380 | 300 | .2 | 6,761,929 | 409 | 7,860,425 | 6,798 |
| Nevada | 37,513 | 6,022 | 16.1 | 33,303 | 2,050 | 6.1 | 31,886 | 224 | .7 | 5,838,463 | 4,523 | 5,941,165 | 12,819 |
| New Hampshire | | | | 3,500 | 47 | 1.3 | | | | | | 3,500 | 47 |
| New Mexico | 1,925 | 2,975 | 19.9 | [c] 137,696 | 949 | .7 | | | | 3,718,339 | 183 | 3,870,950 | 4,107 |
| Oklahoma | | | | | | | 1,406,900 | 12,115 | .9 | | | 1,406,989 | 12,115 |
| Oregon | 49 | 8 | 16.3 | | | | | | | 159,022 | 6 | 159,071 | 14 |
| South Dakota | 62 | 18 | 29.0 | | | | | | | 1,870,721 | | 1,870,783 | 18 |
| Tennessee | | | | | | | 702,326 | 16 | | 482,495 | | 1,184,821 | 16 |
| Texas | 147 | 25 | 17.1 | | | | 443 | | | 52,442 | | 53,032 | 25 |
| Utah | 665,217 | 79,631 | 12.0 | 461,866 | 20,025 | 4.3 | 18,400 | 115 | .6 | 12,775,160 | 974 | 13,920,643 | 100,745 |
| Virginia | | | | 30,961 | 728 | 2.4 | 4,480 | | | 3,821 | | 30,262 | 728 |
| Washington | 9,099 | 2,510 | 27.7 | 17,039 | 189 | 1.1 | 154 | | | 138,706 | 1 | 164,998 | 2,700 |
| Wisconsin | | | | | | | 3,066,500 | 3,043 | .1 | | | 3,066,580 | 3,043 |
| | 7,841,079 | 450,047 | 5.7 | 2,871,248 | 99,637 | 3.5 | 20,384,762 | 52,670 | .3 | 58,224,287 | 20,621 | 89,321,376 | 622,975 |
| Percentage of total lead derived from each kind of ore | | 72.3 | | | 16.0 | | | 8.4 | | | 3.3 | | 100.0 |

[a] By-product from unknown quantity of fluorspar ore. [b] Estimated. [c] Includes zinc ore.

## LEAD SMELTERS.

### ACTIVE SMELTERS AND REFINERIES.

#### UNITED STATES.

CALIFORNIA: Selby—Selby Smelting & Lead Co.[1] Refinery also.
COLORADO:
Denver—Globe plant, American Smelting & Refining Co.
Durango—Durango plant, American Smelting & Refining Co.
Leadville—Arkansas Valley plant, American Smelting & Refining Co.
Pueblo—Pueblo plant, American Smelting & Refining Co.
Salida—The Ohio & Colorado Smelting & Refining Co.[2]
IDAHO: Kellogg—Bunker Hill & Sullivan Smelter.
ILLINOIS:
Aurora—Aurora Metal Co.[3]
Chicago—Goldsmith Bros.' Smelting & Refining Co.[3]
Chicago—Great Western Smelting & Refining Co.[3]
Collinsville—St. Louis Smelting & Refining Co.[4] Refinery only.
Federal—Federal Lead Co.[1]
INDIANA:
East Chicago—International Lead Refining Co.[5] Refinery only.
Grasselli—United States Metals Refining Co.[6] Refinery only. Betts electrolytic process.
KANSAS: Galena—Galena Smelting & Manufacturing Co.[7]
MISSOURI:
Desloge—Desloge Consolidated Lead Co.
Granby—Granby Mining & Smelting Co.
Herculaneum—St. Joseph Lead Co.
Joplin—Eagle-Picher Lead Co.
Webb City—Webb City Smelting & Manufacturing Co.[7]
MONTANA: East Helena—East Helena plant, American Smelting & Refining Co.
NEBRASKA: Omaha—Omaha & Grant Smelting Co.[3] Refinery only. Betts electrolytic process.
NEW JERSEY:
Newark—Balbach Smelting & Refining Co. Refinery also.
Perth Amboy—Perth Amboy plant, American Smelting & Refining Co. Refinery also.
PENNSYLVANIA: Carnegie—Pennsylvania Smelting Co. Refinery also.
TEXAS: El Paso—Kansas City Consolidated Smelting & Refining Co.[1]
UTAH:
Midvale—United States Smelting Co.[6]
Murray—Murray plant, American Smelting & Refining Co.
International—International Smelting Co.[8]
WASHINGTON: Northport—Northport Smelting & Refining Co.[9]

#### CANADA.

BRITISH COLUMBIA: Trail—Consolidated Mining & Smelting Co. of Canada (Ltd.). Refinery also. Betts electrolytic process.
ONTARIO: Kingston—North American Smelting Co. (Ltd.).

#### MEXICO.

AGUASCALIENTES: Aguascalientes—American Smelting & Refining Co.
CHIHUAHUA:
Chihuahua—American Smelting & Refining Co.
Uruachic—Uruáchic Mining & Smelting Co. (Ltd.).
COAHUILA:
Saltillo—Mazapil Copper Co. (Ltd.).
Torreon—Compañía Metalúrgica de Torreón.[2]

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[1] Subsidiary of American Smelters Securities Co.
[2] Subsidiary of American Metal Co.
[3] Smelters of secondary materials but treating some lead ores.
[4] Subsidiary of National Lead Co.
[5] Subsidiary of Anaconda Copper Mining Co.
[6] Subsidiary of United States Smelting, Refining & Mining Co.
[7] Subsidiary of Eagle-Picher Lead Co.
[8] Subsidiary of American Smelting & Refining Co.
[9] Affiliated with Pennsylvania Smelting Co.

DURANGO:
Asarco (Velardena)—American Smelters Securities Co.
Mapimi—Compañía Minera de Penoles.[1]
GUERRERO: Campo Morado—Reforma Mining & Milling Co.
NUEVO LEON: Monterey—American Smelting & Refining Co.
SAN LUIS POTOSI:
Matehuala—American Smelters Securities Co. (National Metallurgical Co.)
San Luis Potosi—Compañía Metalúrgica Mexicana.
SONORA:
Guaymas—Pacific Smelting & Refining Co. (Mexican-American Smelting & Refining Co. (Ltd.).
Ures—Yaqui Smelting & Refining Co., S. A. Refinery also.
ZACATECAS: Chalchihuites—National Smelting Co.

### SMELTER CHANGES.

The Northport Smelting & Refining Co., Northport, Wash., in March blew in its remodeled lead smelter with two 250-ton lead furnaces and later began the construction of two additional furnaces. Construction was started on the Bunker Hill Smelter, at Kellogg, Idaho, to consist of three 300-ton furnaces and adequate refining capacity.

## TRADE CONDITIONS.

### WORLD'S PRODUCTION.

In the following table the production of lead in the world from 1910 to 1913, inclusive, has been calculated to short tons from the statistics published by the Metallgesellschaft, of Frankfurt-am-Main, Germany, with the exception of the substitution of the figures collected by the United States Geological Survey for the production of the United States. Similarly, the production for 1914 to 1916, inclusive, has been taken from Quin's "Metal handbook and statistics," 1919, with the exception of output of the United States. As shown on a preceding page, considerable lead has been smelted and refined in the United States in the last seven years from ores produced in Africa and South America, but the production of those countries is not given separately in the table, being included in the figures for "Other countries" for 1910 to 1913.

*World's production of lead, 1910–1916, in short tons.*

| Country. | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| Australia | 108,907 | 109,789 | 118,387 | 127,867 | 107,520 | 113,733 | 152,762 |
| Austria-Hungary | 19,390 | 21,605 | 23,589 | 26,565 | ..... | ..... | ..... |
| Belgium | 44,364 | 48,832 | 56,438 | 55,997 | ..... | ..... | ..... |
| Canada | 10,535 | 11,795 | 17,968 | 18,849 | 18,465 | 22,700 | 21,000 |
| France | 22,366 | 26,014 | 34,282 | 30,864 | ..... | ..... | ..... |
| Germany | 174,604 | 181,218 | 194,666 | 199,627 | ..... | ..... | ..... |
| Great Britain | 32,628 | 28,660 | 32,187 | 33,620 | 22,248 | 17,659 | 14,000 |
| Greece | 18,519 | 15,763 | 15,963 | 20,282 | 23,166 | 12,986 | 10,555 |
| Italy | 15,963 | 18,408 | 23,699 | 23,920 | 22,920 | 24,429 | 27,200 |
| Japan | 3,358 | 4,630 | 4,960 | 3,968 | 5,111 | 5,336 | 12,500 |
| Mexico | 133,048 | 137,347 | 132,276 | 68,343 | 31,000 | 62,000 | 30,000 |
| Russia | 1,323 | 1,102 | 1,102 | 1,102 | ..... | ..... | ..... |
| Spain | 211,531 | 193,013 | 205,799 | 223,767 | 158,207 | 192,049 | 165,095 |
| Sweden | 441 | 1,213 | 1,433 | 1,653 | 1,564 | 2,148 | 2,324 |
| Turkey in Asia | 13,999 | 13,668 | 13,779 | 15,322 | ..... | ..... | ..... |
| Other countries[a] | 17,306 | 22,597 | 13,448 | 6,834 | 11,814 | 7,750 | 12,410 |
| United States (domestic refined) | 375,402 | 391,995 | 392,517 | 411,878 | 512,794 | 507,026 | 552,228 |
| | 1,210,504 | 1,227,649 | 1,282,513 | 1,270,458 | ..... | ..... | ..... |
| United States percentage of world production | 31.0 | 32.0 | 30.6 | 32.4 | ..... | ..... | ..... |

[1] Subsidiary of American Metal Co.

[a] Includes Burma only, 1914–1916.

## IMPORTS AND EXPORTS.

### WAREHOUSE TRANSACTIONS.

Lead imported into the United States as metal or in ore may be entered for immediate consumption, the duty being paid and the lead going direct to the consumer; or it may be entered for warehouse, bond being given for double the amount of the estimated duty. In the accompanying tables the phrase "general imports" indicates the total imports, including both lead entered for immediate consumption and lead entered for warehouse. From warehouse the lead may be withdrawn for consumption by payment of duty, or it may remain in bond for smelting and refining, finally being either withdrawn for consumption or exported from warehouse with cancellation of bond. The lead entered for immediate consumption and that withdrawn from warehouse for consumption make up the "imports for consumption," which are expressed in the same terms as those under which they were imported. The lead imported for consumption may be actually used in this country, or it may be manufactured into articles which are exported; in the latter event the manufacturer is entitled to the benefit of a drawback of 99 per cent of the duties paid. In the table below, showing foreign led exported in manufactures with benefit of drawback, the lead is shown in the form in which it was originally imported. On account of diversity of form it is not feasible to show the articles exported with benefit of drawback. The foreign lead given in the table below as exported from warehouse is likewise shown in the form in which it was imported and entered for warehouse. Foreign lead exported from warehouse has, since July 1, 1915, been included by the Bureau of Foreign and Domestic Commerce in the domestic exports as "from foreign ore."

The items foreign lead exported from warehouse, domestic exports of lead "from foreign ore," and foreign lead exported in manufactures with benefit of drawback make up the total foreign lead going out of the country. Lead in warehouse and deductions by liquidation being disregarded, the difference between the sum of these exports of foreign lead and the total imports of lead constitutes the foreign lead consumed in this country. For the sake of simplicity this foreign lead is carried on the bonded customs warehouse records in the form in which the lead was entered until the bond is canceled. It must be clearly understood, therefore, that the lead listed in the table of foreign exports of lead, on a later page, was not exported as lead content of ore and base bullion but as refined lead smelted and refined from them. Since 1914, however, all foreign lead exported has been classed as lead, "pigs and bars," except a portion of the articles manufactured from foreign lead and exported with benefit of drawback. For articles not made wholly of lead it would be useless to give weights, but each shipment on which drawback is claimed is accompanied by a manifest of the imported lead used in making the articles and the duty paid thereon. From these manifests is derived the statement of the total quantity of foreign lead used in manufactures exported with the benefit of drawback. For this reason the lead is given in the form in which it is imported.

The following table is taken from the reports of the Bureau of Foreign and Domestic Commerce. For the reasons given above, the lead is shown in the terms in which it was imported. For instance, a considerable part of the lead stated as remaining in ore and base bullion doubtless represents refined lead waiting at the bonded refinery for a favorable market for shipment. If this is borne in mind, the table gives a fair idea of the fluctuations of foreign stock at different times and in different localities.

*Lead remaining in warehouse in the United States, Dec. 31, 1910–1916, in pounds.*

| | Form in which lead was entered for warehouse. | | Remaining at— | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | New York. | | Chicago, Ill. | El Paso, Tex. | St. Louis, Mo.[a] | San Francisco, Cal. |
| | Lead in ore and base bullion. | Pigs, bars, and old. | Newark, N. J. | Perth Amboy, N. J. | | | | |
| 1910 | 71,794,443 | 149,082 | 7,548,936 | 36,112,136 | 21,090,631 | 6,937,667 | ..... | ..... |
| 1911 | 8,869,713 | 93,082 | 2,777,692 | 2,308,322 | 954,884 | 2,555,733 | 273,082 | ..... |
| 1912 | 20,891,182 | 93,802 | 1,890,828 | 17,666,768 | 484,671 | 767,533 | 91,382 | ..... |
| 1913 | 10,620,953 | ..... | 8,785,551 | | 80,880 | 1,683,091 | 71,431 | ..... |
| 1914 | 15,333,064 | 3,867 | 10,309,592 | | 94,775 | 4,802,961 | 125,736 | ..... |
| 1915 | 24,338,933 | ..... | 8,401,728 | | 165,257 | 14,678,809 | 104,922 | 988,217 |
| 1916 | 23,667,358 | 1,070,298 | 8,575,115 | | 4,732,535 | 6,814,844 | 3,286,189 | 258,675 |

[a] Kansas City before 1914.

## IMPORTS.

The following tables are taken from the reports and records of the Bureau of Foreign and Domestic Commerce:

*Lead imported and entered for consumption in the United States, 1910–1916.*

| Year. | Lead in ore. | | Base bullion. | | Pigs, bars, and old. | | Sheets, pipe, and shot. | | Not otherwise specified. | Total value. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity (pounds). | Value. | Quantity (pounds). | Value. | Quantity (pounds). | Value. | Quantity pounds. | Value. | | |
| 1910 | 7,998,859 | $198,196 | 16,543,167 | $337,223 | 6,776,066 | $212,858 | 39,779 | $1,972 | 4,843 | $755,092 |
| 1911 | 1,474,254 | 28,563 | 17,376,459 | 352,595 | 7,112,749 | 242,423 | 63,151 | 2,855 | 7,218 | 631,654 |
| 1912 | 935,861 | 24,760 | 22,729,467 | 462,559 | 5,191,823 | 110,459 | 31,184 | 2,305 | 5,468 | 605,551 |
| 1913 | 2,306,972 | 75,835 | 17,665,227 | 388,116 | 4,621,270 | 105,738 | 39,171 | 3,291 | 12,710 | 572,980 |
| 1914 | 5,459,961 | 188,749 | 8,904,649 | 301,195 | 575,290 | 12,281 | 62,552 | 2,753 | 81,894 | 504,978 |
| 1915 | 2,865,792 | 96,010 | 15,496,230 | 519,355 | 997,368 | 32,951 | 201,510 | 17,059 | 107,580 | 772,955 |
| 1916 | 10,125,983 | 368,824 | 5,242,171 | 208,277 | 6,388,097 | 331,235 | 532 | 63 | 106,560 | 1,014,959 |

*Type metal imported and entered for consumption in the United States, 1904–1916.*

| Year. | Type metal. | | Lead content.a | |
|---|---|---|---|---|
| | Gross weight (pounds). | Value. | Quantity (pounds). | Percentage. |
| 1904 | 8,143,749 | $221,127 | 6,884,423 | 84.5 |
| 1905 | 13,932,013 | 456,155 | 11,476,929 | 82.4 |
| 1906 | 19,602,471 | 900,608 | 15,896,929 | 81.1 |
| 1907 | 14,832,673 | 932,027 | 12,095,027 | 81.5 |
| 1908 | 4,110,486 | 156,847 | 3,265,815 | 79.5 |
| 1909 | 13,993,889 | 532,108 | 11,339,378 | 81.0 |
| 1910 | 13,394,199 | 485,493 | 11,176,830 | 84.9 |
| 1911 | 8,390,470 | 310,858 | 6,936,711 | 82.7 |
| 1912 | 581,411 | 18,668 | 477,006 | 82.0 |
| 1913 | 567,004 | 20,098 | 467,088 | 82.5 |
| 1914 | 1,509,538 | 45,373 | 1,322,188 | 87.6 |
| 1915 | 2,768,261 | 107,607 | 2,424,306 | 87.6 |
| 1916 | 1,162,386 | 83,816 | 923,473 | 79.4 |
| Average lead content, 1904–1916 | | | | 82.2 |

a Prior to 1904 the lead content of the type metal was not given. Besides lead, the chief constituent of the type metal is antimony.

*General imports of lead into the United States, in ore, base bullion, and refined, 1910–1916, by sources, in pounds.*

| Country. | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| United Kingdom | 1,874,750 | 401,686 | 279,546 | 404,594 | 245,548 | 185,236 | 261,406 |
| Germany | 421,377 | 56,286 | 494,237 | 262,132 | 4,529,919 | ..... | ..... |
| Other European countries | 418,669 | 111,189 | 55,356 | 143,293 | 123,085 | 32,537 | 314,353 |
| Total from Europe | 2,714,796 | 569,161 | 829,139 | 810,019 | 4,898,552 | 217,773 | 575,759 |
| Canada | 206,979 | 270,947 | 319,497 | 338,569 | 384,007 | 2,303,170 | 12,606,216 |
| Mexico | 203,290,307 | 172,633,479 | 159,455,664 | 95,603,439 | 46,282,207 | 94,247,384 | 48,395,670 |
| South America | 6,598,263 | 4,778,221 | 3,207,936 | 8,766,327 | 2,417,744 | 5,420,567 | 6,235,758 |
| Other countries | 4,394,421 | 1,651,544 | 3,309,356 | 8,685,612 | 2,694,293 | 802,516 | 2,845,949 |
| Total imports | 217,204,766 | 179,903,352 | 167,121,592 | 114,293,966 | 56,676,803 | 102,991,410 | 70,659,352 |

*General imports of lead into the United States, 1910–1916, by classes, in pounds.*

| Year. | Lead in ore (lead content). | Base bullion. | | Pigs, bars, sheets, and old. | Total lead content. |
|---|---|---|---|---|---|
| | | Gross weight. | Lead content. | | |
| 1910 | 94,751,054 | 118,061,415 | 115,483,542 | 6,970,170 | 217,204,766 |
| 1911 | 35,666,180 | 141,481,852 | 138,952,372 | 5,284,800 | 179,903,352 |
| 1912 | 19,577,499 | 152,420,624 | 146,999,168 | 544,925 | 167,121,592 |
| 1913 | 19,883,313 | 96,908,170 | 94,327,654 | 82,999 | 114,293,966 |
| 1914 | 23,649,637 | 33,444,503 | 32,730,320 | 296,846 | 56,676,803 |
| 1915 | 18,185,140 | 86,247,995 | 83,986,988 | 819,282 | 102,991,410 |
| 1916 | 35,086,100 | 24,943,660 | 24,262,435 | 11,310,817 | 70,659,352 |

*Basic carbonate white lead, red lead, litharge, and orange mineral, imported and entered for consumption in the United States, 1911–1916.*

| Year. | Corroded white lead. | | Red lead. | | Litharge. | | Orange mineral. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | | *Pounds.* | |
| 1911 | 741,071 | $46,213 | 1,063,533 | $42,471 | 24,662 | $1,196 | 504,734 | $28,515 |
| 1912 | 687,705 | 46,494 | 757,908 | 33,854 | 32,443 | 1,550 | 334,551 | 20,914 |
| 1913 | 672,109 | 45,266 | 99,832 | 4,903 | 34,023 | 1,750 | 330,525 | 22,205 |
| 1914 | 596,567 | 40,203 | 12,554 | 2,934 | 33,651 | 1,805 | 240,388 | 16,388 |
| 1915 | 339,157 | 24,608 | 1,968 | 132 | 20,650 | 1,422 | 171,572 | 14,061 |
| 1916 | 88,617 | 8,050 | 20,467 | 5,302 | 1,320 | 150 | 70,934 | 8,281 |

## EXPORTS.

### DOMESTIC EXPORTS.

The average difference between the prices of lead at New York and at London for the 10 years prior to 1914 was not far from 1½ cents a pound and the price at New York was the higher. This being the case, exports of domestic pig lead should be expected only under temporary or very unusual circumstances. The practice of the Bureau of Foreign and Domestic Commerce has been to class all exports of lead articles manufactured in this country as domestic exports, whether the lead is of domestic or foreign origin. For this reason no table of exports of domestic lead manufactures has been given, because such a table would duplicate the table showing foreign lead in manufactures exported with benefit of drawback. Since the exports of domestic pig lead began, however, they have been shown separately.

In 1914 the price of lead at London rose above the price at New York early in January and remained between one-fourth and one-half cent a pound above throughout the year. This made it possible to export domestic lead at a profit, and the decrease in imports of lead ore and bullion from Mexico rendered it necessary to satisfy the foreign demand with domestic lead, the exports of which assumed large proportions. The movement commenced in March, 1914, and by the end of the year 58,722 short tons, valued at $4,501,674, had been exported. Likewise in 1915 the price of lead at London was from one-fourth to 1 cent a pound higher than the price at New York, except for the period of high prices in the United States during June and July. Exports of domestic lead continued heavy throughout the year, reaching a total of 88,306 tons, valued at $7,928,518. In 1916 the exports of domestic lead amounted to 100,500 tons and were valued at $13,494,065.

*White lead exported from the United States, 1913–1916.*

| | Quantity (pounds). | Value. |
|---|---|---|
| 1913 | 15,062,384 | $905,398 |
| 1914 | 17,645,538 | 1,017,376 |
| 1915 | 25,310,369 | 1,409,622 |
| 1916 | 27,435,054 | 2,137,072 |

### FOREIGN EXPORTS.

By foreign lead exports are meant the exports of lead of foreign origin which has been smelted, refined, or manufactured in this country and then shipped abroad. The following table, made up from the records of the Bureau of Foreign and Domestic Commerce, shows the total lead exported for a period of years; but it must be borne in mind, as pointed out on a previous page, that prior to 1915 the actual exports were not in the form shown in the table, which is the import form, but instead consisted of refined lead and lead manufactures. Since July 1, 1915, the exports of foreign lead heretofore classed as "ore," "base bullion," and "pigs, bars, and old" are all included in "pigs, bars, and old" as domestic manufactures of lead

from foreign ore. The quantities given for lead exported from warehouse are exact, but the quantities given for lead in manufactures are subject to the waste in manufacturing.

*Foreign lead exported from the United States, 1910–1916.*

| Year. | Exported from warehouse. | | | | | | | Exported in manufactures with benefit of drawback. | |
|---|---|---|---|---|---|---|---|---|---|
| | Lead content of ore. | | Lead content of base bullion. | | Pigs, bars, and old. | | All other manufactures. | Lead content of ore. | Pigs, bars, bullion, and old. |
| | Quantity (pounds). | Value. | Quantity (pounds). | Value. | Quantity (pounds). | Value. | Value. | Quantity (pounds). | Quantity. (pounds). |
| 1910 | 22,508,090 | $248,220 | 117,045,333 | $2,262,057 | 19,507 | $703 | $870 | 6,592,294 | 11,008,604 |
| 1911 | 39,276,820 | 730,247 | 151,986,265 | 3,093,290 | 12,311,102 | 244,037 | 1,504 | 674,621 | 23,485,929 |
| 1912 | 12,796,703 | 219,859 | 116,907,305 | 2,478,256 | 107,170 | 3,826 | 2,121 | 150,617 | 22,584,221 |
| 1913 | 11,721,714 | 271,985 | 77,253,891 | 1,827,538 | 111,506 | 4,851 | 3,422 | 74,628 | 19,484,345 |
| 1914 | 6,724,525 | 245,205 | 10,944,350 | 378,286 | 25,421,500 | 913,306 | 2,242 | 4,040,924 | 14,970,669 |
| 1915 | (a) | ..... | (a) | ..... | 77,236,303 | 2,738,263 | 40,112 | 7,966,372 | |
| 1916 | (a) | ..... | (a) | ..... | 19,760,086 | 1,111,653 | 541 | 10,341,075 | |

a Since July 1, 1915, the Bureau of Foreign and Domestic Commerce has classed all foreign lead exported as "domestic exports, of pigs, bars, etc., produced from foreign."

## CONSUMPTION.

In statements of consumption of lead in these reports prior to 1907 it was the custom to take into account the smelter stocks of lead at the beginning and at the end of the year. It is not to be denied that for the individual year this gives closer figures. It is just as true that account of trade stocks should also be taken to arrive at accurate results; but this is manifestly outside the scope of the work of this Survey. It has been found impossible to obtain a statement of stocks from one large producer since 1906; hence consumption has been calculated without reference to domestic stocks. A very considerable part, however, from one-fourth to one-fifth of the lead smelted and refined in this country, is lead of foreign origin smelted in bond, and it is possible to obtain statistics of the stocks of this part for they are reported annually by the Bureau of Foreign and Domestic Commerce as "merchandise remaining in warehouse at close of year." A certain element of error is introduced by the fact that the imports, the exports, and the warehouse stocks, as given, include lead in both ore and base bullion. So far as imports are concerned, the relative quantities of lead in ore and of base bullion are shown on a preceding page in the table entitled "Imports of lead, by classes," based upon the records of the Bureau of Foreign and Domestic Commerce, and corroborated in the preceding table giving the "sources of primary lead smelted or refined in the United States," based upon smelter reports. For exports and warehouse stocks no such division can be made, because they are classified according to the condition of the metal when it was imported and no change is made with the reduction of the metal in bond. Nevertheless, it is deemed advisable to use warehouse stocks as giving a better estimate of consumption. It is necessary, therefore, to include all classes of lead imports as well as all classes of lead exports.

In the following table "lead" includes all kinds—lead in ore, base bullion, pigs, bars, and old. The figures of domestic production are based upon the returns by the smelters; all other figures are taken from the records of the Bureau of Foreign and Domestic Commerce. Liquidation changes cover losses in smelting and refining in bond and other corrections. Because warehouse stocks are used in lieu of smelter stocks the result given below is lead "available for consumption." The "apparent consumption" would be this quantity increased or diminished by the increase or decrease of domestic stocks during the year.

*Primary lead available for consumption in the United States, 1910–1916, in short tons.*

| | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|
| Supply: | | | | | | | |
| Stock in bonded warehouses Jan. 1 | 17,405 | 35,972 | 4,481 | 10,492 | 5,310 | 7,668 | 12,169 |
| Imports: | | | | | | | |
| For consumption | 15,679 | 13,013 | 14,444 | 12,316 | 7,501 | 9,780 | 10,878 |
| For warehouse | 92,923 | 76,939 | 69,117 | 44,831 | 20,837 | 41,716 | 24,452 |
| Increase by liquidation | | | | | | 2,250 | 5,642 |
| Production from domestic ores | 375,402 | 391,995 | 392,517 | 411,878 | 512,794 | 507,026 | 552,228 |
| Apparent supply | 501,409 | 517,919 | 480,559 | 479,517 | 546,442 | 568,440 | 605,369 |
| Deduction: | | | | | | | |
| Export of foreign lead: | | | | | | | |
| From warehouse | 69,786 | 101,787 | 64,906 | 44,544 | 21,545 | 38,618 | 9,830 |
| In manufactures, with benefit of drawback | 8,800 | 12,080 | 11,367 | 9,757 | 9,506 | 3,983 | 5,171 |
| Exports of domestic lead | | | | | 58,722 | 88,306 | 100,500 |
| Decrease by liquidation | 7,661 | 14,812 | 5,692 | 419 | 56 | | |
| Stock in bonded warehouses Dec. 31 | 35,972 | 4,481 | 10,492 | 5,310 | 7,668 | 12,169 | 12,369 |
| Total deduction | 122,219 | 133,160 | 92,457 | 60,030 | 97,497 | 143,076 | 127,920 |
| Available for consumption | 379,190 | 384,759 | 388,102 | 419,487 | 448,945 | 425,364 | 477,449 |

## PRICES AND VALUE.

The price of lead began the year at New York at 5.5 cents a pound, the minimum of the year, and rose to 8 cents early in April, the maximum. A long decline carried the price down to 5.95 cents a pound in the early part of August. It rose to 7 cents about the middle of September, after which it remained stationary until early in December, when it advanced to 7.5 cents, and it closed the year at about that figure. The average New York price for the year was 6.9 cents, compared with 4.7 cents in 1915, 3.9 cents in 1914, and 4.4 cents in 1913. These are the figures used in calculating the value of the lead produced in the United States during those years.

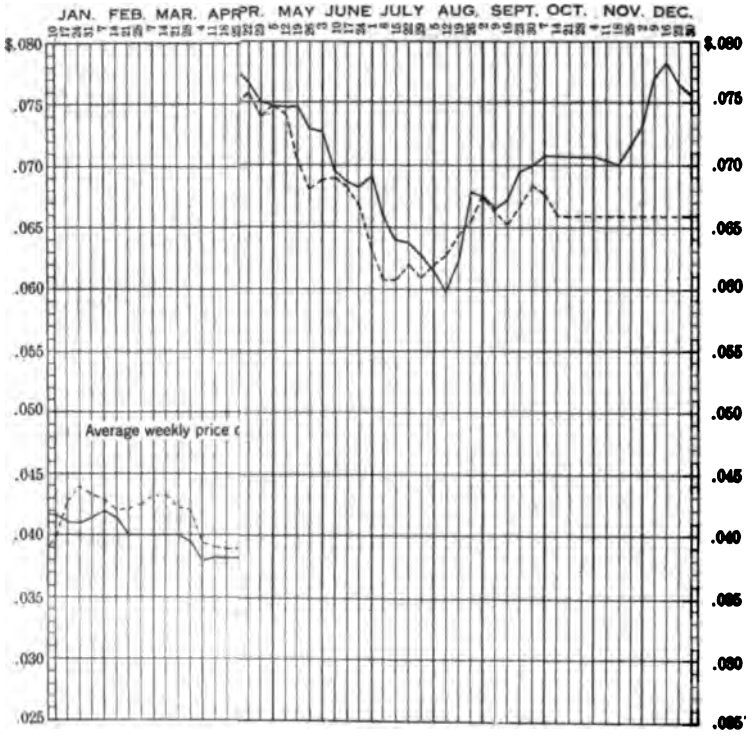
The London price of lead was higher than the New York price in the first quarter of the year but below it in almost the whole of the last three quarters. The London price started the year at £30 7s. 6d. a long ton (6.57 cents a pound) and rose to £36 7s. 6d. a ton (7.87 cents a pound) in the later part of March. Paralleling the New York market, a long decline brought the price down to £28 a ton (6.06 cents a pound) in July, at which it remained through the month. A sharp rise followed by a decline and another rise brought the price up to £31 10s. a ton (6.82 cents a pound) late in September. A decline to £30 10s. a ton (6.6 cents a pound) took place early in October, after which the price remained practically stationary. The

average price of lead at London during 1916 was £30 19s. 6d. a long ton (6.6 cents a pound).

The fluctuations in the price of lead at New York and London are graphically shown in Plate III, which gives curves of the average weekly price of lead in those markets for the years 1914,1915, and 1916.

As stated on page 837, the value of the output of refined lead in the United States from domestic ores in 1916 was $76,207,000, at the average price of refined lead in New York, as compared with $47,660,000 in 1915, a gain of $28,547,000, or nearly 60 per cent.

1916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$.080
.075
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.030
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Average weekly price

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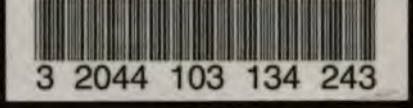
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